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Assessing eHealth knowledge diffusion within the public health sector in Kenya using social network analysis

in partial fulfilment of the requirements for the degree: MPhil in Health Innovation

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Date: November 2019

Declaration

I, *Dr Ryan Nyotu Gitau*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abstract

High disease morbidity coupled with limited healthcare personnel places the health sector in Kenya under strain, leaving parts of the population with limited access to health services. Electronic health (eHealth), the utilisation of information and communication technologies in healthcare, is an innovation with the potential to improve access to health services. Several examples exist of eHealth projects being undertaken in Kenya. However, eHealth solutions have been poorly adopted in the public healthcare sector, which has partly been blamed on lack of knowledge amongst healthcare providers and patients.

The aim of this study was to examine how knowledge is exchanged between the stakeholders currently active within the eHealth implementation space in the Kenyan public sector. The results of the study would aid in identifying communication breakdowns and ways of increasing information flow with regard to eHealth, and ultimately would aid strategies to help improve the uptake of eHealth within the public sector.

A mixed methods study was undertaken that combined quantitative social network analysis and qualitative analysis of semi-structured interviews conducted with stakeholders involved in implementation of eHealth projects in Kenya. Publications on implementation of eHealth projects in Kenya from 2001 to 2018 were used to obtain data on relevant organisations. Social network analysis was used to identify prominent actors. Individuals working within such organisations were invited to participate in semi-structured interviews. Further social network analysis was applied to data gathered through the interviews.

Foreign universities and foreign not-for-profit organisations were the most commonly identified organisations in the networks generated. The tacit nature of knowledge within networks, low research capacity and output, information guarding, geographical distance between collaborating organisations, and low cohesion were some of the factors found to inhibit knowledge diffusion within the eHealth implementation space in Kenya. The search for capacity and funding were found to contribute to network structure. eHealth knowledge management strategies should be given attention, for enhanced exchange of knowledge within the public health sector in Kenya.

Acknowledgments

There are many people without whom this dissertation would not have seen the light of day.

I would first like to thank my supervisor Professor Tania Douglas for the patience, support, belief and guidance you have accorded me throughout this research project. I am particularly grateful to you for introducing me to the science of knowledge and networks. Working under your mentorship has provided me with legitimation of the belief that it is possible for innovations from Africa to scale across the continent and the world at large.

I would then like to thank the Mandela Rhodes Foundation for giving me the opportunity to study and conduct research at the University of Cape Town, for providing a community of like-minded young Africans with whom we can dream and build towards a better tomorrow.

Thank you to the Kenyan eHealth implementers who agreed to participate in this study and all the support you provided. Your time is greatly appreciated.

I would also like to thank the Health Innovation group for providing a safe space for growth and enriching discourse. May this network keep growing from one level to the next!

To my brother Letian, thank you for receiving me as you did, creating a home away from home. To Mum, Dad, Njeri, Seine and Waweru, your constant prayers and words of encouragement provide me with the energy and courage to keep on moving.

To Ngakuya, thank you for at 100 years you are still setting an example of how to live fearlessly and with integrity. Thank you Cucu Maria Nyotu for the sacrifices you have made so that I may have this opportunity.

Lastly, to my wife Dr Njeri Ndung'u. You are the best team-mate I could ever have hoped for. I still remember that it is you who first pointed out that UCT has a course in Health Innovation. Thank you for the sacrifice you have taken for me to do this work. Thank you for your belief in me and for your patience. You have shown me love through deeds and I will not forget that this dissertation would not have been possible without you.

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List of acronyms

eHealth	Electronic health
GOK	Government of Kenya
HIS	Health information systems
ICT	Information and Communication Technologies
KDHS	Kenya Demographic and Health Survey
KEHIA	Kenya Health Informatics Association
KEMRI	Kenya Medical Research Institute
KNBS	Kenya National Bureau of Statistics
KNH	Kenyatta National Hospital
mHealth	Mobile health
MOH	Ministry of Health
NGO	Non-Governmental Organisation
SNA	Social Network analysis
UON	University of Nairobi
WHO	WORLD Health Organisation

1. Introduction

The population of Kenya is 46.7 million people and is poised to grow at a rate of one million people per year (KDHS, 2014; KNBS, 2019). This rapid population growth is a cause of strain on the health sector, which has to contend with high maternal mortality of 362 per 100,000 live births and a high under-five mortality of 39 per 1000 live births (KDHS, 2014). There is also a concomitant increase in the prevalence of preventable, non-communicable diseases even among the lower social economic groups, with stroke and ischemic heart disease being among the top 10 causes of death. It is estimated that non-communicable diseases now account for almost 27% of deaths and 50 % of total hospital admissions in Kenya (KDHS, 2014; KNBS, 2016). The ratio of practicing health workers to population is also low. As of 2015, the ratio of practicing doctors, dentists and nurses was 1.5 doctors, 0.2 dentists and 8.3 nurses per 10,000 population, which is low when compared against the World Health Organisation (WHO) minimum recommendations of 36 doctors and 25 nurses per 10,000 population (GOK, 2015a; WHO, 2015; WHO, 2016b).

The healthcare sector in Kenya has been undergoing many changes since it was decentralised, in August 2013, creating 47 autonomously running healthcare administrative systems called counties (GOK, 2010). This was done primarily to bring essential services closer to the population. Decentralisation presented an administrative and logistical challenge due to what was perceived as a shortage of competent healthcare managers to work within the new administrative units (Whimp, 2012). It had been previously noted that novel and innovative approaches would be critically needed in order to prevent, or reduce the time needed to recover from, the anticipated disruption that would arise from this gap in management (Whimp, 2012).

eHealth is such an innovation. eHealth is broadly defined as the utilisation of information and communication technologies in healthcare. Relevant technologies include telemedicine, mobile devices (mHealth), and health information systems, among others (WHO, 2016a). (WHO, 2006). eHealth is capable of providing support to healthcare systems, health practitioners and patients by acting as a tool to bridge the ever-widening health worker to patient gap (Betjeman, Soghoian & Foran, 2013). There are already examples of it being used

to increase adherence to drugs, to aid health workers' communication with patients, to promote health education initiatives, as well as to aid in the management of disaster or emergency situations, especially in developing countries (Betjeman, Soghoian & Foran, 2013; Blaya, Fraser & Holt, 2010; Owolabi et al., 2018).

The uptake of eHealth in developing countries has been slow (Holmner et al., 2012). Poor support of eHealth activities by government, due to reasons like competition for resources with other existing projects and a lack of evidence of cost effectiveness, has been mentioned as a cause of such poor uptake (Betjeman, Soghoian & Foran, 2013; GOK, 2017b; Holmner et al., 2012). A lack of appropriate eHealth policies has been highlighted as a significant challenge, with some researchers arguing that governments that develop such policies are more likely to adopt eHealth technologies (Holmner et al., 2012 citing; Lang & Mertes, 2011). Many developing countries have only recently started to formulate their national eHealth policies. Without localised and contextual information, they risk adopting policies from developed countries in a 'one size fits all' approach that would be detrimental to the development of functional and context-appropriate eHealth policies (Mars & Scott, 2010). The Kenya National eHealth Policy (2016-2030), which was launched in 2017, highlighted poor infrastructure, low literacy levels, inadequate technical expertise, unreliable power supply, limited funding and lack of government involvement in eHealth projects as some of the key challenges the country needs to address in order to better capitalise on the benefits of eHealth (GOK, 2017b).

The WHO (2006) believes that if it is to achieve its strategic focus of using eHealth to strengthen health systems among its member states, there is a need to investigate, document and analyse the impact of eHealth. There is a paucity of information on assessment of eHealth technologies in developing countries like Kenya. Njoroge et al. (2017), in a systematic review assessing different eHealth initiatives in the country, found that not only were there few such projects that were successfully scaled into the public sector, there was also a geographically uneven distribution of such initiatives with little to no evaluation of most projects. Njoroge et al. found that eHealth projects have been marked by fragmentation and duplication, which points to a divergence of thought, values, and approaches amongst the stakeholders. This is problematic as proper implementation of eHealth will require a collaborative partnering

among stakeholders who possess different resources, knowledge and contextual experiences (Nielsen & Mengiste, 2014).

Adoption of a technology requires a transfer of knowledge between different stakeholders (Klarl, 2009b). Knowledge can take several forms within a network. These include tacit (embodied) knowledge, which is described as a form of knowledge gained by learning or experience; in contrast, explicit (codified) knowledge is readily accessible as it exists away from the generator of the knowledge, for example in print form (Reagans & McEvily, 2003; Su, Yang & Zhang, 2017). Strong networks are required in order to facilitate knowledge transfer (Hansen, 1999). Social network analysis is a tool that can be used to map out the relationships between stakeholders in a network. It is described as a highly graphical and structured way of conducting research that focuses on the relationships between all the players in a sector in order to more appropriately understand how information flows within the network (Luke & Harris, 2007; Serrat, 2017). It has been used in public health to describe social support and capital within different health networks, to understand organisational networks and to help visualise the transmission of disease and information (Luke & Harris, 2007; Valente & Pitts, 2017). Social network analysis tools can generate information on the state of the interactions and therefore knowledge flows among stakeholders and delineate their roles in the innovation adoption network as well as their capacity to receive and utilise such knowledge. Such information on the stakeholders involved in eHealth implementation in Kenya would be beneficial to the health system. At this early point of changes within the health sector in Kenya, such insights will aid in identifying communication breakdowns and ways of increasing information flow with regard to eHealth, and ultimately will aid strategies to help improve the uptake of eHealth within the public sector.

1.1. Aim and Objectives

The aim of this study was to examine how knowledge is exchanged between the stakeholders currently active within the eHealth implementation space in the Kenyan public sector.

The specific objectives to be carried out in the study were:

- To identify and characterise the stakeholders involved in the implementation of eHealth in the public sector.

- To show the structure of relationships between the stakeholders of the currently implemented eHealth projects within the public sector in Kenya.
- To examine the flow of eHealth knowledge in Kenya by identifying the barriers between stakeholders and the potential for improved knowledge flow.

1.2. Project scope

Stakeholders in this study are defined as any individuals or organisations involved in the design, distribution, implementation, utilisation, evaluation or regulation (Ballejos & Montagna, 2008) of eHealth solutions in Kenya. Different stakeholders are described based on the role they hold during development and implementation of eHealth projects. The definitions provided by Ballejos & Montagna for different categories of stakeholders are used. End user is a term used to describe those stakeholders who are beneficiaries, i.e. those who gain from the implementation of a project, be it through functional, financial or political rewards, or operators, i.e. those who interact and use the system and its outputs, regardless of whether or not they gain from such an interaction. Implementers is a term used to describe the decision makers (those in charge of eHealth projects), experts and consultants (those whose technical knowledge is sought during the implementation phase) and developers (those who play a direct role in the development of the systems).

This study combined quantitative social network analysis techniques with qualitative research methods. The social network analysis allowed for the structure of the relationships to be drawn out and described using network metrics and diagrams. This allowed for the identification and characterisation of the stakeholders active within the sector. Thematic analysis of the semi-structured interviews provided insights on the knowledge present within the sector and the context within which it flows.

1.3. Overview of dissertation

Chapter 2 reviews the literature relevant to the study. Chapter 3 describes the methodology, namely extracting network data on eHealth project implementation in Kenya and also conducting and analysing semi-structured interviews with eHealth implementers. Chapter 4

presents the results of the study. Chapter 5 provides a discussion of the results and makes suggestions for the direction future work can take.

2. Literature review

This literature review focusses on eHealth as a tool that is already being used across the African continent. The chapter also considers social network analysis as a tool that can be used to provide insights on stakeholder interactions in health systems.

2.1. eHealth in Kenya

The WHO defines eHealth as the utilisation of information and communication technologies in healthcare. This refers to technologies like telemedicine, mHealth applications and health information systems, among others (WHO, 2006). Increasing healthcare costs and the widening doctor-to-patient ratio in many countries has caused a shift towards increased implementation of digital health solutions (Ragaban, 2016). This is evidenced by the fact that as of 2012, eHealth has had an almost pan-African presence with South Sudan being the only country that did not have eHealth projects (Scott, Mars & Hebert, 2012). Scott et al. (2012) showed widespread utilisation of eHealth in different areas of specialty like radiology, cardiology, dermatology, ophthalmology. Across the African continent, different eHealth technologies like mHealth, defined as the use of mobile devices for healthcare (WHO, 2011), have been used to improve medical adherence, health worker communication, health education initiatives as well as in cases of disaster and emergency management (Betjeman, Soghoian & Foran, 2013).

The first e-health project in Kenya was launched in 2001 and since then many advances have taken place with 69 projects having been launched in Kenya as identified by Njoroge et al. (2017). The government of Kenya, having identified the value and potential of eHealth to the Kenyan healthcare sector, launched the Kenya National eHealth Policy (2016-2030) in 2017. This policy sought to streamline and guide the implementation of different eHealth projects around the country by starting the process of creating a framework to ensure provision of networked care in a professional and equitable manner (GOK, 2017b). This is important as a market analysis of the Kenyan healthcare sector found that access to healthcare services and products was not equal (Davis et al., 2019). This inequality has also been identified in the implementation of eHealth projects in the country with Njoroge et al. (2017). reporting that little effort had been put into reaching the marginalised regions of the country, with 24 of 69

projects reviewed in the study being implemented in Nairobi while some counties did not even have one eHealth project. Other studies have also found limited application of eHealth in the western rural part of the country with a lack of basic tools, like computers and reliable internet connections among others, needed for appropriate eHealth technology (Ouma & Herselman, 2008). Despite such infrastructural impediments, good potential has been suggested for the uptake of mHealth, even in marginalised zones, with Kazi et al. (2017) reporting that over 82% of respondents seeking antenatal care and immunizations in clinics in rural and marginalised parts of Kenya had access to a mobile phone and 92% of them saying they would like to receive text messages with health content weekly.

2.1.1. Implementation and evaluation of eHealth projects

Several eHealth projects have been implemented in Kenya but knowledge on their success, challenges, benefits to patients and cost effectiveness is limited. The lack of such data has been highlighted as one of the top four reasons standing in the way of eHealth project implementation (Kay, Santos & Takane, 2011).

A systematic review conducted to describe the eHealth initiatives implemented from 2001-2015 in Kenya showed that evaluation of projects was as an area that was found to be wanting (Njoroge et al., 2017). Of the 69 projects documented, only 28 had been evaluated after implementation, with only two of the projects scaled nationally being evaluated (ibid).

Evaluation techniques are required that are not only able to focus on the technical and cost aspects of eHealth, but also on the social and cultural factors affecting proper implementation. Of the 28 projects identified by Njoroge et al. (2017), eight projects were assessed using randomised control trials that focussed mostly on whether the eHealth modality implemented had any positive effect, with even fewer cases providing a cost effectiveness brief. Other methods used to evaluate the projects identified were non-randomised intervention studies, cross sectional studies, cohort studies, feasibility and acceptability studies. (Njoroge et al., 2017).

Understanding the implementation challenges faced in eHealth projects will assist in the development of evaluation methods that are standardised to ensure high quality is maintained across the implemented projects. In the context of eHealth, this means that there

is a need for documenting what infrastructure is present versus what is needed, assessing the awareness levels of both the public and the healthcare practitioners, and understanding stakeholder engagement, while highlighting the challenges and benefits of eHealth to the end user (Odhiambo, 2015). The exchange of knowledge between stakeholders is a goal of stakeholder engagement.

2.2. Knowledge diffusion

Generating and acquiring knowledge has been described as a critical requirement for innovation and growth to occur within a country (Cowan & Jonard, 2004; Singh, 2005). Knowledge diffusion refers to how knowledge, in whichever form, is able to spread within a network (Klarl, 2009a). For there to be increased adoption of a technology, the information and knowledge present and available to implementing stakeholders such as those in academia (knowledge generators) and within innovation circles (early adopters), needs to be able to be transferred to the end user stakeholders such as those involved in its distribution and utilisation (Klarl, 2009b). Strong networks are required to facilitate the transfer of this type of information, and relationships between stakeholders have been identified as a factor that can affect how knowledge flows between them (Hansen, 1999). The type of knowledge also has a bearing on how efficiently knowledge will flow (Su, Yang & Zhang, 2017). It is more likely for actors who are familiar with each other to pass knowledge to each other by leveraging both the strength of their relationship and the cohesion of their network (Reagans & McEvily, 2003). Complex knowledge requires more resources (like time and money) to transfer and therefore one would not be willing to transfer the knowledge without adequate motivation like incentives or friendships (Su, Yang & Zhang, 2017).

Effective implementation of eHealth will require a collaborative partnering among stakeholders who possess different resources, knowledge and contextual experiences (Nielsen & Mengiste, 2014), and thus will require effective flow of knowledge between these stakeholders. An assessment of knowledge diffusion would be aided through understanding of the structure of the network and relationships between stakeholders.

2.3. Social Network Analysis

Social network analysis (SNA) is a method that provides a means to understand the dynamics and inner workings of a system by bringing to the fore the interactions between individual stakeholders within a network (Ragaban, 2016). By utilising social network analysis, researchers are able to graphically map out both formal and informal relationships, thereby providing insights into what parts of the system promote and inhibit the flow of knowledge by showing how the different stakeholders interact (Wasserman & Faust, 1994).

Early SNA work within the health sector was able to create visual representations of how ties like sharing needles among intravenous drug users contribute to the transmission of contagious diseases (Eames & Keeling, 2002 as referenced by; Luke & Harris, 2007). Studying the structure of social networks also allows for the visualisation of how information on a new innovation spreads within a network; proximity to sources of information has been found to have a positive effect on how fast public health initiatives and innovation like family planning are taken up and used (Luke & Harris, 2007).

SNA has been used in public health to describe social support and capital within different health networks. Network analysis techniques are able to show how individuals in a network relate with each other to draw resources from their social circles and how this has an effect on health behaviours like smoking, mental health, morbidity and even mortality for different groups of people (Luke & Harris, 2007). SNA has also been used to show that past interactions between public health organisations within a network had an influence on future collaborations and funding between organisations (ibid). Recent work on SNA has seen it being used to describe how international aid organisations come together to work and achieve their objective of improving child health outcomes and how their position, relationships and activities within the network affect their ability to receive and transmit knowledge and material resources (Han, Koenig-Archibugi & Opsahl, 2018).

SNA methods have utility in assessing how organisations interact with each other to produce their desired outcomes. An African context example of this is the utilisation of SNA to explore and describe the relationships, and the outcomes of such relationships, within the medical device development landscape in South Africa (Chimhundu, de Jager & Douglas, 2015; de

Jager, Chimhundu & Douglas, 2017). These studies relied on co-authorship of publications to indicate collaboration between the stakeholders. By assessing collaboration, de Jager, Chimhundu & Douglas (2017) were not only able to identify who the main stakeholders were in medical device development, but were also able to show their importance in the information exchange process and how this evolved over a period of time. Despite the many advantages of using co-authorship as a proxy for collaboration there are several limitations like the emphasis on the academic sector (i.e. basic or scientific knowledge production) and neglect of collaborations that are not represented in publications like applied or technological knowledge production (de Jager, Chimhundu & Douglas, 2017).

SNA has also been utilised to assess the "connectedness" of connected health, which is a term used to refer to "a new socio-technical model for healthcare management which exploits the use of information technology (IT) for clinical or wellness decision-making tasks" (Carroll & Richardson, 2017). These authors conducted an exploratory literature review which aimed to show the suitability of SNA to model a healthcare network within which such technology will be used and concluded that SNA is suited to describing the dynamic nature of healthcare service delivery as opposed to other methods like process improvement models which usually focus on individual static parts of the system.

In assessing the development of eHealth in Lithuania from the stakeholder point of view, SNA was used to investigate whether the legitimate interests of the stakeholders (the policy makers, the implementers and users of eHealth) were well represented (Jankauskienė, 2014). The researchers sought to assess the role of the stakeholders, and to describe the main long term and short-term obstacles for innovation and sustainability, in the delivery of the healthcare services. The analysis was also used to highlight the nature of cooperation while describing the dynamics that govern these relationships.

2.4. Summary

Several challenges like a lack of evaluation of the projects, fewer projects being implemented in marginalised areas and fragmentation when it comes to implementation have been outlined as limiting the success of eHealth (Njoroge et al., 2017). These challenges have however not been analysed in great depth. Poor eHealth uptake has largely been blamed on

lack of knowledge on the value of eHealth by both the government and end user (Kay, Santos & Takane, 2011). As effective eHealth implementation would require coordinated efforts across all stakeholders, assessing how knowledge flows between them may provide new insights as to how to leverage the current network to increase efficient implementation of eHealth projects. Social network analysis provides a tool for the assessment of knowledge flow across stakeholder networks.

3. Methodology

This study describes the stakeholders (actors) playing a role in eHealth in the public sector in Kenya and the knowledge flow among them. The actors and their activities were identified and the interactions that influence knowledge diffusion within the networks were examined. The objectives were achieved through social network analysis, using data collected from available published literature and from interviews with stakeholders.

3.1. Study design

A mixed methods study was conducted that combined quantitative and qualitative research methods. Quantitative social network analysis (SNA) methods were used to describe the nature of the relationships between the actors (Schipper & Spekkink, 2015). The actors were organisations active in eHealth in Kenya. Semi-structured interviews were conducted with members of relevant organisations and transcribed and verified. Thematic analysis of the semi-structured interviews was then used as it is useful for the identification, coding and visualisation of important points from the point of view of the actors in a network of interest (Bazeley & Jackson, 2013; Joffe, 2012). These qualitative data were used to describe the context and content of the knowledge flowing between the actors.

A whole network research design was used to extract detailed information about the structure of the eHealth knowledge network across the country. This is an approach in which all the identified organisations and their relationships with regard to knowledge diffusion are examined (Borgatti, Everett & Johnson, 2018).

Figure 1 shows the study design. It shows that two networks, i.e. publication and interview-based networks, were drawn. Publication-only social network analysis focusses more on academic stakeholders rather than industry stakeholders because the former are the organisations that publish more often (Chimhundu, de Jager & Douglas, 2015). Thus interviews with stakeholders identified in the publication network were used to identity further relevant stakeholders, through snowball sampling, which is advantageous in identifying hard to reach stakeholders within a network (Atkinson & Flint, 2001).. A second network was drawn, showing the stakeholders thus identified.

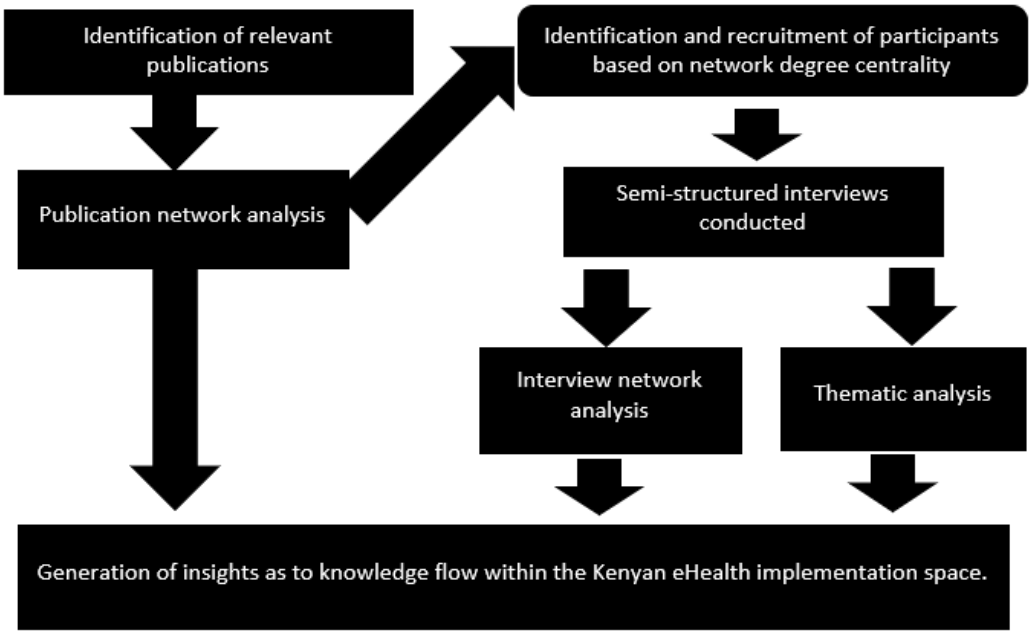

Figure 1: Study design flowchart

3.2. Ethics

Ethics approval was sought and obtained from the Faculty of Health Sciences at the University of Cape Town (reference number HREC REF 760/2018) and the Ethics and Scientific Research Committee from AMREF Health Africa in Kenya (reference number ESRC P604/2019). Approval was also obtained from the National Council for Science Technology and Innovation in Kenya, which is the government body that approves research to be done in the public sector (reference number NACOSTI/P/19/68013/30012).

3.3. Social network analysis

Publications on eHealth in Kenya were used to identify projects and actors for the SNA. The systematic review conducted by Njoroge et al. (2017), which produced a list of publications on eHealth projects implemented in Kenya from 2001 to 2015, was used as a starting point for the SNA. The criteria used in the review, were used to identify publications available after the period studied by Njoroge et al., i.e. from 2015 to March 31st, 2018. A search was conducted in PubMed, Web of Science and Google Scholar repositories. The same search terms used in the systematic review were used as shown below:

"Kenya AND eHealth OR mHealth OR Health information systems OR telemedicine OR telemed OR text messaging OR SMS OR e-learning OR electronic health record OR electronic health"

A search of national newspaper articles, websites and government publications was also done for grey literature. The content of the publications was reviewed to determine whether the project was implemented in Kenya. Any publications that did not fulfil these criteria were excluded. Authors who collaborated on the publications or implementation projects were considered representatives of the organisations to which they were affiliated. Organisations were therefore considered to be collaborating on the implementation of eHealth projects in Kenya if they had co-authored a paper together or if the publications overtly said that there was a partnership between the organisations during any phase of development and implementation of an eHealth project in the country.

3.3.1. Stakeholders

Data on organisations extracted from the literature were represented as adjacency matrices (Borgatti, Everett & Freeman, 2002) and analysed using Microsoft Excel (2013). This was done in order to address the first objective that sought to identify and characterise the stakeholders involved in the implementation of eHealth projects in the country.

The identified organisations were first categorised into four groups based on the type of eHealth technology being implemented. Based on the four strategic areas of implementation previously described as active within the Kenyan eHealth space (Njoroge et al., 2017), the following categories of eHealth were used in this study: mHealth, health information systems, telemedicine, and other eHealth types. The latter included any other type of eHealth technology that was not associated with the above categories, for example eLearning platforms, eResearch and the internet of things (IoT) in health care.

The organisations were then organised and sorted according to regions based on their country of origin. This was done by accessing the websites of identified organisations and identifying the country where the organisation was first incorporated and based. The organisations were then also organised by type of organisation for example organisations linked to government, universities, not-for-profit organisations, for-profit organisations,

research organisations and hospitals. This information was gathered by examining how the organisations self-describe themselves on the 'about' section of their website, for example as a for-profit organisation.

3.3.2. Networks

UCINET was used to extract network metrics while the visualisation was achieved using the network visualisation tool NetDraw (Borgatti, Everett & Freeman, 2002).

The social network data represented as adjacency matrices were imported into the UCINET matrix editor where they were saved and named as UCINET network data files. Data describing the attributes of the identified organisations were also entered and saved as network attribute files. The attributes that were used to analyse and visualise the network were the following:

- Identity - This was represented as an abbreviation of the organisation name as coded in the adjacency matrix.
- Category - This refers to information on the type of organisation and the location of their incorporation and was coded using numbers.

The data were then analysed using network metrics. In network analysis the actors are referred to as nodes and the relationships between them as ties (Hanneman & Riddle, 2005).

Various network metrics were calculated, based on network characteristics, or node characteristics. The features of nodes, for example their position within the network, may accord an advantage when it comes to access to and provision of knowledge within the network (Borgatti, Everett & Johnson, 2018). The network metrics calculated are described below.

- Network density

This metric provides information on how closely connected different types of actors are to each other within a network. It considers the total number of actual ties present between the nodes relative to the maximum number of ties that could potentially be present between all the nodes. A network structure with a high network density (close to 1) indicates that most nodes within a network are connected to one another while one approaching 0 indicates that

most actors in the network are not connected to each other (Patterson et al., 2013). This is important because it affects the cost, in terms of time and resources spent, and efficiency of knowledge transfer. For efficient diffusion of knowledge, certain factors like being closely acquainted with the source of the knowledge (strong ties) or existing in a structure with strong third party ties, will foster cooperation (Reagans & McEvily, 2003; Su, Yang & Zhang, 2017). Network density is calculated by dividing the ties present by the total number of possible ties (Hanneman & Riddle, 2005).

- Degree centrality

Degree centrality refers to the number of ties a particular node has within a network. It indicates the likelihood that a node will receive information flowing through the network (Borgatti, Everett & Johnson, 2018). It can also provide information about the importance and role of a particular node within the structure (Hanneman & Riddle, 2005). A node with a high degree will be associated with increased importance within the entire network.

- Betweenness centrality

This metric describes the importance of a node with regard to controlling the flow of knowledge within the network. A node with a high betweenness score has high influence over the flow of information in the network. Betweenness centrality is calculated by assessing how many times a node lies along the path between any two other nodes in the network (Borgatti, Everett & Johnson, 2018).

- Closeness centrality

When assessing knowledge flows, closeness centrality describes the distance of a node to all others. This means that nodes that have a high closeness score are close to the source of new knowledge irrespective of where in the network the knowledge comes from. It is calculated by summing up the shortest distance from one node to each of the other nodes in the network (Borgatti, Everett & Johnson, 2018).

Centrality values were normalised by dividing the values obtained in each network by the maximum possible value for each centrality measure and expressing it as a percentage (Wasserman & Faust, 1994). This was done to allow for comparison of the results between the networks despite the difference in total number of actors for each.

NetDraw was used to visualise the data as shown in Figure 2: An illustration of how different nodes (organisations) are presented in a network. Ties or edges, drawn as lines between nodes, represents connections between nodes. Nodes are distinguished by shape (denotes type of organisation) size (the larger the node, the more ties it has) and colour (Kenyan actors vs foreign). The thickness of edges can be used to show increased tie strength between two nodes.. Node sizes were set based on the individual node degree centrality while the strength of connections or ties between nodes was illustrated by the thickness of the connecting lines.

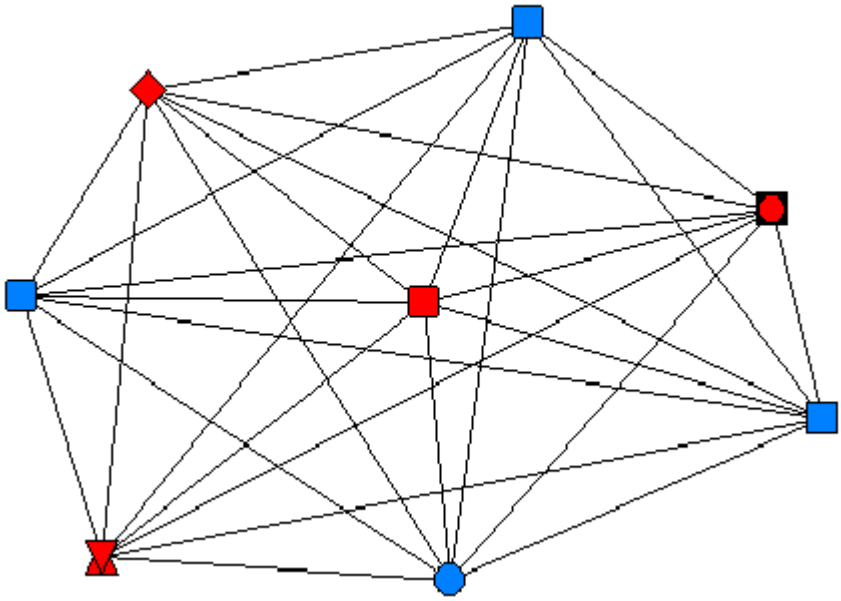

Figure 2: An illustration of how different nodes (organisations) are presented in a network. Ties or edges, drawn as lines between nodes, represents connections between nodes. Nodes are distinguished by shape (denotes type of organisation) size (the larger the node, the more ties it has) and colour (Kenyan actors vs foreign). The thickness of edges can be used to show increased tie strength between two nodes.

3.4. Semi structured interviews

Qualitative interviews provided a flexible and time efficient method to capture the thoughts and perceptions of different eHealth stakeholders with varying levels of experience and expertise in a private setting. This allowed for free and flowing descriptions (Newcomer et al., 2015) of the opportunities and challenges in the eHealth sector in Kenya. The interviews allowed the participants to describe their challenges in their own words and from their own

point of view without the need to sanitise their feelings; interviews are also useful in extracting information on what services different organisations offer, their attitudes and behaviours and on how such behaviours can be changed, improved, or modified (Newcomer et al.,2015). In assessing knowledge diffusion using SNA, one expected outcome is the generation of new insights into the participant interactions that influence knowledge flows within the sector, with a view to improving such interactions.

Qualitative interviews were conducted with stakeholders from different organisations that have been involved in developing and implementing eHealth projects within the public health sector in Kenya. Participants for the qualitative interviews were identified using the social network analysis on existing literature on eHealth projects implemented in Kenya. The top five organisations were ranked according to the group centrality scores for the four strategic areas of implementation. This meant that some organisations featured more than once as they were active in more than one strategic area of implementation. For the purpose of identifying stakeholders for interviews, the organisations were ranked according to how many times they appeared in the ranked lists. The top ranked organisations were then contacted via email and face-to-face interactions and asked to identify individuals who were actively engaged with eHealth work from within the organisation. Informed consent was then sought from the identified individuals who were invited to take part in the study.

The initial interview questions collected information on demographics, geography and on how long the organisation had been active within the eHealth sector. The interviews also sought to extract information on knowledge diffusion i.e. what sort of eHealth knowledge each participant had, how and from where they acquired it, and how it had been spread to other stakeholders within the network. The respondents were then asked to describe their experiences and views during the implementation phases, addressing the following three areas:

- The nature of the journey of working as an implementer of eHealth in the Kenyan public health sector.
- The techniques considered and implemented for training end users and other implementing partners on, for example, adoption of a new technology, as well as the associated experiences.

- The locations in the network where technical support is sought, for example for conducting impact assessments of the implemented projects.

The information sought, plays a role in determining the type of interaction that is required between the participants in order for knowledge transfer to occur between organisations (Klarl, 2009a). The interviews sought to elicit whom the participants seek as sources of knowledge and their capacity to transmit and receive relevant information. This is important as it has been shown that the nature of the knowledge and the ability of the participants to receive and transmit the knowledge has an effect on the efficiency of knowledge diffusion (Mu, Tang & MacLachlan, 2010; Su, Yang & Zhang, 2017). The interviews also looked to identify the context and format in which this knowledge is transferred from one participant to the other. The frequency of the interactions and subjective importance placed on the interactions was also assessed (Borgatti, Everett & Johnson, 2018).

Snowball sampling was used to identify additional participants. An advantage of the snowball sampling technique is that it is effective in identifying participants who are difficult to reach either because they are active on the ground or have positions in high places with regard to societal power dynamics for example high ranking government officials (Atkinson & Flint, 2001).

Name generators were incorporated into the interviews. A name generator is a question that extracts information about the network by asking the participants to name and describe others with whom they have relationships thereby facilitating the gathering and extraction of information on different network types (Shakya, Christakis & Fowler, 2017). Name generators have been shown to be the most effective method of extracting information on a specific network (Bien, Marbach & Neyer, 1991). They have been used in different network analysis studies conducted in low to medium income countries to identify different forms of relationships among participants (Perkins, Subramanian & Christakis, 2015).

Name generators are important as they provide a context linking the individual participants interviewed to the network structure elucidated (Shakya, Christakis & Fowler, 2017). From the questions, the ties described provide a basis to generate the network structure while the specific question creates the specific context within which the ties operate (Ibid).

Different types of relationships can be elucidated using name generators (Shakya, Christakis & Fowler, 2017). The study focused on knowledge flows between the participants to identify participants who hold which information and how the interactions between them enable the knowledge to become useful to the network (Cross, Borgatti & Parker, 2001). Factual and direct questions were used as name generators as they have been shown to be the most effective in extracting this type of information (Ibid).

The participants were therefore asked the following question as name generator at the end of the interview: "Please suggest other participants within the eHealth network that you have worked with from the top of your head." Prodding questions were added that sought to elicit the nature of the work, the purpose, duration and outcomes of the interactions.

3.4.1. Stakeholders

The same protocol was followed for the network analysis as in section 3.3.1 with the difference being that the network generated from the interviews was not analysed according to the strategic areas of implementation. This was done because majority of the organisations identified for the interviews were active in more than one area of eHealth and as such could not be categorised in this manner. There were also low numbers of organisations identified in some of the strategic areas. The network generated from the literature review and the one generated from the direct interviews were compared in terms of composition and network structure metrics (Hanneman & Riddle, 2005).

3.4.2. Thematic analysis

Thematic analysis is a qualitative research analysis technique that seeks to extract meaning in the form of themes by identifying and analysing emergent trends from data (Bazeley & Jackson, 2013). It allows for the combination of theoretical ideas (deductive) that the researcher may have, to be used together with ideas that emerge from the data collected from the actors interviewed (inductive) in the study. It was preferred in this study design as it allowed for the context around which eHealth is implemented in Kenya, to be elucidated using the thoughts and understanding of the actors themselves (Bazeley & Jackson, 2013; Joffe, 2012).

NVivo software (Bazeley & Jackson, 2013) was used for analysis of the information collected from the interviews, thus allowing for coding of data based on different themes. Thematic coding facilitated the analysis of the types of network relationships that have been shown to be of interest when assessing knowledge flow, i.e. the collaboration network (De Lange, Agneessens & Waege, 2004). Cross & Sproull (2004) demonstrated that by seeking information from others within a network, a stakeholder can gain knowledge in form of solutions, metadata, legitimisation, problem reformulation and validation.

Each interview transcript was assessed and any part of it that had to do with an area of interest, guided by the study research question, was highlighted and saved under a general label. This phase resulted in the organisation and tagging of parts of the data into codes prior to analysis of emerging themes. The codes were then assessed in order to identify meaning from them generate different themes and subthemes. These were then reassessed against the research question and transcripts to make sure they were aligned. The end result of this was reorganisation of themes and subthemes with some being combined to form new themes or some being reduced to be subthemes under other themes.

The results of the qualitative analysis were linked to the results of the network analysis for a clearer description of how and why knowledge diffusion occurs within the network (Jankauskienė, 2014).

Word queries and other tools available on NVIVO 12 were used to aid in visualisation of the available data (Bazeley & Jackson, 2013).

4. Results

This chapter is divided into two broad sections: one dealing with analysis of the data obtained from publications and the other dealing with analysis of the data collected from the semi-structured interviews.

4.1. Publication networks

A total of 123 projects were identified in the literature that fit the criteria described in section 3.3. Sixty-nine had been identified from the systematic review on eHealth projects in Kenya (Njoroge et al., 2017), while 36 new projects were identified from publications identified from PubMed, 20 from Web of Science and Google Scholar repositories and 11 from general Google searches, searches of government databases and eHealth company websites. Duplicate publications were removed. The remaining publications were assessed based on the projects they addressed. In some cases, different publications were found to be reporting on different aspects or different stages of the same project. Nine such publications were identified. Stakeholders (organisations) were identified from 127 retained projects.

Table 1 shows the results of data collected from the publications. A total of 230 organisations were identified within the eHealth sector in Kenya. When analysed according to the strategic areas of implementation, mHealth was the most active with 170 organisations identified, followed by Health information systems (61), then other forms of eHealth (40) and finally telemedicine (15). Academia and not-for-profit organisations made up the bulk of organisations identified in all networks identified from publications. When the Kenyan organisations were viewed in isolation, local for-profit organisations and not-for-profit entities were found to make up the bulk of the organisations. Table 2 shows the organisations identified by the area of implementation and the region of registration of the organisations. Most organisations active within the sector were found to be based in either Kenya or the United States of America.

A network was drawn for each of the four eHealth areas. The size of the nodes is determined by the degree centrality of the node with the edge weighted to illustrate the tie strength between the organisations (how many times the different organisations have worked together).

Table 1: Organisations sorted according to strategic areas of technology implementation and organisation type. HIS - health information systems

Abbreviations	Organisational type	mHealth	HIS	Other eHealth	Telemedicine
G	Government (county or central)	7	3	2	1
IG	Foreign government	1	1	0	0
LU	Local university (within Kenya)	4	3	5	0
FU	Foreign university	48	17	8	3
FNPO	Foreign not-for-profit organisation	43	15	7	3
LNPO	Local not-for-profit organisation	15	5	5	1
IRO	Foreign research organisation	6	1	0	0
LRO	Local research organisation	2	1	0	0
LH	Local hospitals	10	4	5	4
IH	Foreign hospital	7	2	0	0
IPC	Foreign for-profit	12	3	3	1
LPC	Local private company	15	6	5	2
	Total	170	61	40	15

Table 2: Distribution of organisations according to strategic area of implementation and region of registration. HIS – health. Information systems

Region	mHealth	HIS	Other eHealth	Telemedicine
Asia	6	1	0	0
Europe	31	10	0	1
Africa region excluding Kenya	7	0	0	1
Kenya	51	22	21	7
Americas	75	28	19	6

4.1.1. MHealth publication network

One hundred and seventy organisations were identified as active within the mHealth network. Foreign universities (48) and foreign not-for-profit organisations (43) made up most organisations identified within this network. North America was the most active region with 75 organisations represented. Fifty-one Kenyan organisations were identified, 31 from the European region, 7 from other African countries and 6 from the Asia pacific region. Of the 51 Kenyan organisations, most (30 out of 51) were local private companies (15) and not-for-profit-organisations (15). A network density that is approaching 0 indicates that actors in a network are loosely connected (Patterson et al., 2013). The mHealth network had a network density 0.0416 which indicates that the actors within the network were not closely connected to each other.

Figure 3 shows the collaborative network for organisations dealing with mHealth solutions in Kenya. The Ministry of Health, Kenya Medical Research Institute (KEMRI), the University of Nairobi (UON), Moi University and AMPATH were the locally based organisations that were found to have been involved in many projects while having many collaborating partners. There were also isolated organisations that were not found to have collaborating partners but were active within the eHealth space. This is presented on the left-hand side of Figure 3 as disconnected nodes.

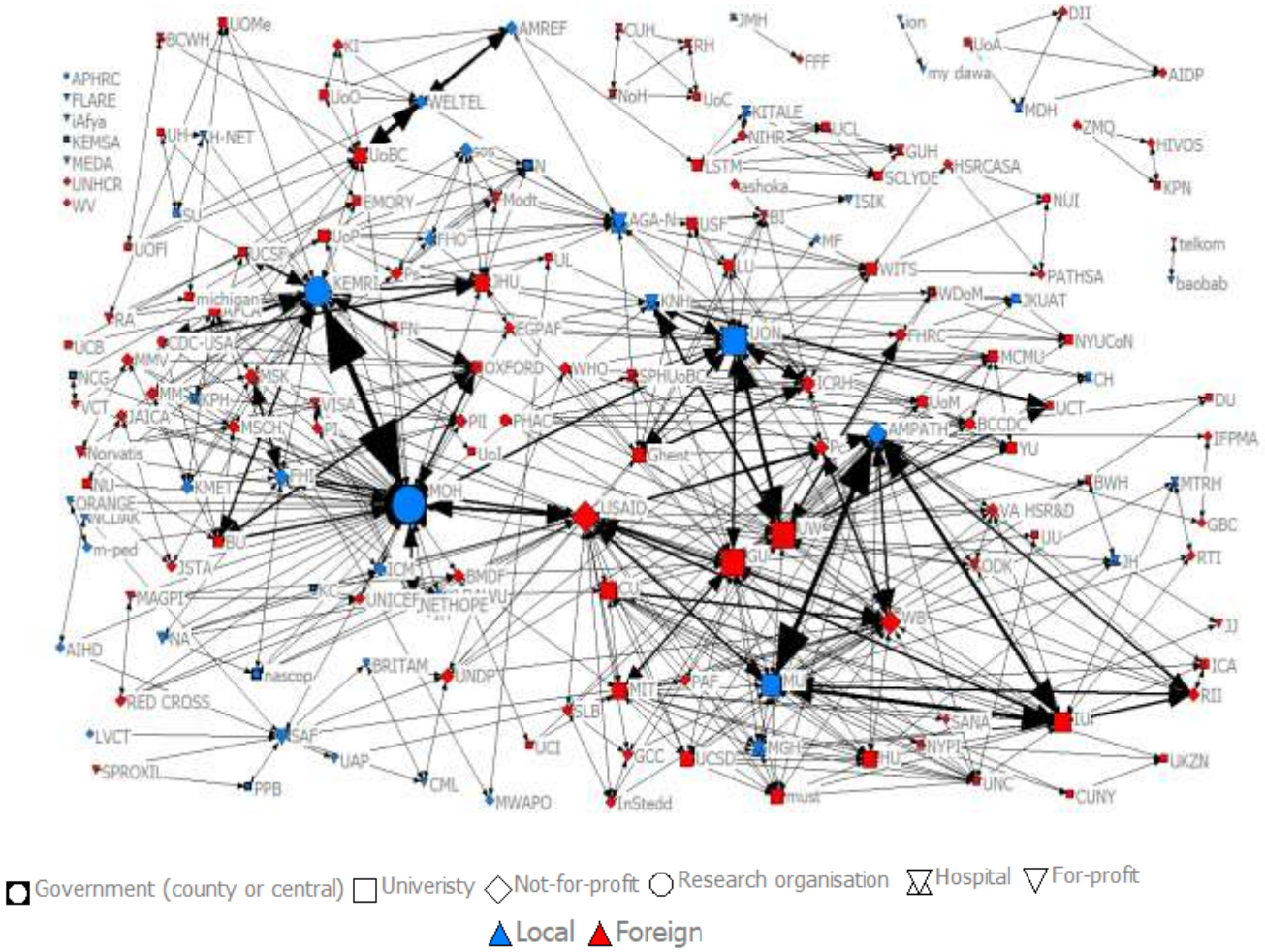

Figure 3: The mHealth publication network from 2001 to March 2018. Nodes are scaled to degree centrality and the edges have been weighted to the number of times organisations have collaborated. Abbreviations are provided in Appendix 1.

Table 3 shows the top 20 organisations sorted from the largest to the smallest with regard to degree centrality. Abbreviations are provided in Appendix 1. The Ministry of Health (MOH) had the highest degree centrality (0.3491) followed by KEMRI, United States Agency for International Development (USAID), the University of Nairobi and the University of Washington. Within the top 20, foreign universities and foreign not-for-profit organisations made up the bulk of organisations identified. This can be interpreted as the Ministry of Health being the node with the largest capacity to transmit information to all other nodes within the network. Table 4 shows the top 20 organisations ranked by their betweenness centrality scores. Universities and not-for-profit organisations made up the majority of the organisations in this rank.

Table 3: Top 20 mHealth organisations ranked according to degree centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Org Abbreviation	Degree Normalised	Rank	Org Abbreviation	Degree Normalised
1	MOH	0.3491	11	CU	0.1065
2	KEMRI	0.2544	12	AGA-N	0.1006
3	USAID	0.2308	13	MIT	0.0947
4	UON	0.2249	14	JHU	0.0947
5	UW	0.2130	15	KNH	0.0888
6	AMPATH	0.1775	16	FHI	0.0888
7	GU	0.1775	17	HU	0.0828
8	MU	0.1716	18	UoBC	0.0828
9	IU	0.1598	19	ICRH	0.0769
10	WB	0.1538	20	Ghent	0.0769

Table 4: Top 20 MHealth organisations ranked according to betweenness centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Org Abbreviation	Category	Betweenness	Rank	Org Abbreviation	Category	Betweenness
1	MOH	1	0.2473	11	LSTM	4	0.0483
2	UON	3	0.1337	12	WB	5	0.0394
3	KEMRI	8	0.1281	13	JHU	4	0.0342
4	UW	4	0.1008	14	CU	4	0.0332
5	GU	4	0.0865	15	WITS	4	0.0294
6	USAID	5	0.0826	16	AMPATH	6	0.0293
7	UoBC	4	0.0732	17	MU	3	0.0194
8	AMREF	6	0.0586	18	UNDP	5	0.0176
9	AGA-N	9	0.0520	19	IU	4	0.0145
10	SAF	13	0.0486	20	KNH	9	0.0140

The MOH, UON and KEMRI, the University of Washington and Georgetown University were the highest ranked in terms of their betweenness centrality scores. This implies that these organisations are best placed to affect and change how information flows within the network.

Table 5 shows the normalised closeness centrality scores. Foreign universities and foreign not-for-profit organisations made up the bulk of the organisations in this top 20 rank. The closeness centrality ranks show that the MOH, the University of Nairobi, KEMRI, Georgetown University and the University of Washington were the highest ranked. This implies that these organisations are closest to new knowledge irrespective of where in the network this knowledge is generated.

Table 5: Top 20 MHealth organisations ranked according to closeness centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Org Abbreviations	Category	Closeness	Rank	Org Abbreviations	Category	Closeness
1	MOH	1	0.3521	11	MSK	5	0.2996
2	UON	3	0.3380	12	FHI	6	0.2986
3	KEMRI	8	0.3301	13	UoBC	4	0.2986
4	GU	4	0.3294	14	ICRH	5	0.2929
5	UW	4	0.3263	15	Ghent	4	0.2929
6	USAID	5	0.3231	16	AMPATH	6	0.2919
7	JHU	4	0.3183	17	MU	3	0.2919
8	KNH	9	0.3107	18	IU	4	0.2914
9	WB	5	0.3067	19	CU	4	0.2914
10	EGPAF	5	0.3034	20	BMDF	5	0.2914

4.1.2. Health information systems publication network

Sixty-one organisations were identified as active collaborators in health Information systems. Foreign universities and foreign not-for-profit organisations made up the majority of the organisations identified.

North American and Kenyan organisations made up the bulk of organisations identified.

Figure 4 presents the health information system network. This network had a network density of 0.1617 meaning that in this network the players were more connected to each other as compared to the mHealth network (Patterson et al., 2013).

The MOH, KEMRI, UON, Moi University, Moi Teaching and Referral Hospital (MTRH) and AMPATH were found to be among the more prominent locally based organisations involved in many projects while having many collaborating partners.

Error! Reference source not found. Table 6 shows the top 20 organisations sorted from the largest to the smallest with regard to degree centrality. The MOH had the highest degree centrality (0.95) followed by Indiana University (IU), AMPATH, Regenstrief Institute Inc. and USAID. Foreign not-for-profit organisations and foreign universities made up the majority of the top 20 organisations identified. These organisations can be interpreted to have the largest capacity to transmit information to all other nodes within the network (Wasserman & Faust, 1994).

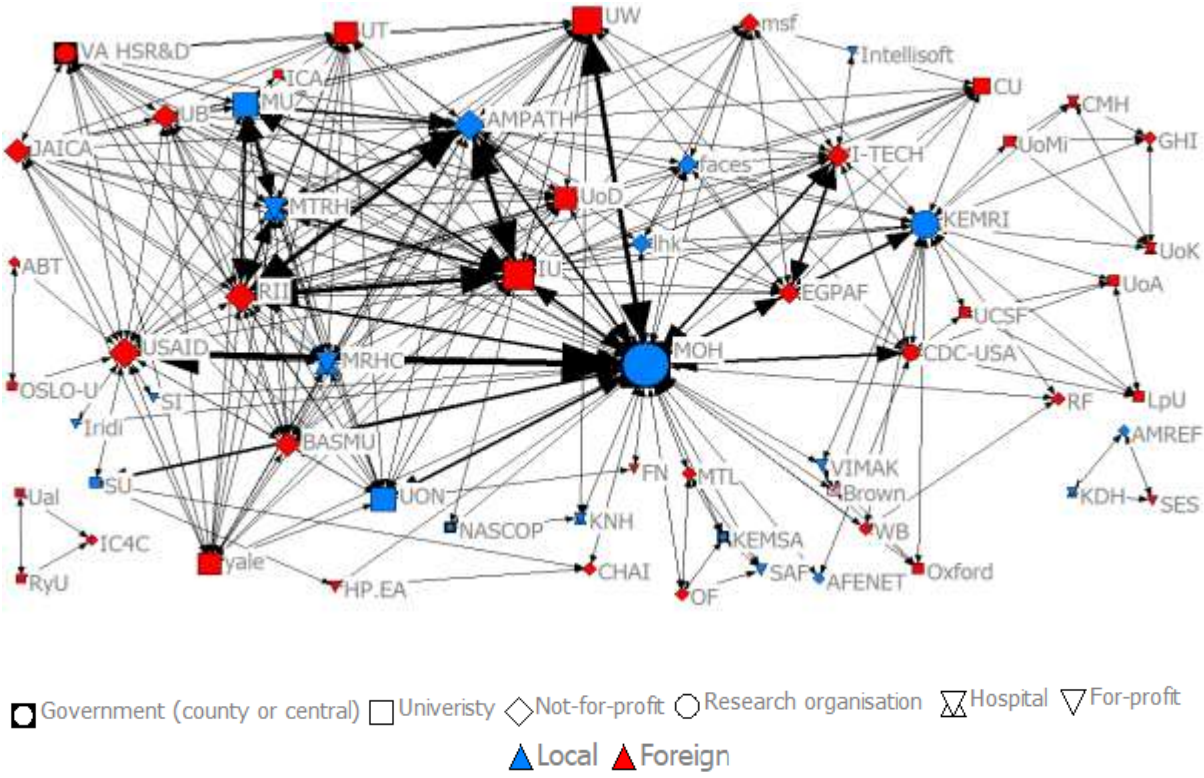

Figure 4: The health information systems publication network from 2001 to March 2018. Nodes are scaled to degree centrality and the edges have been weighted to the number of times organisations have collaborated. Abbreviations are provided in Appendix 1.

Table 6 :Top 20 health information systems organisations ranked according to degree centrality in descending order. Abbreviations are provided in Appendix 1

Rank	Abbreviation	Category	Degree	Degree (Normalised)	Rank	Abbreviation	Category	Degree	Degree (Normalised)
1	MOH	1	57	0.9500	11	VA HSR&D	2	16	0.2667
2	IU	4	31	0.5167	12	JAICA	5	16	0.2667
3	AMPATH	6	30	0.5000	13	UT	4	16	0.2667
4	RII	5	30	0.5000	14	MRHC	9	16	0.2667
5	USAID	5	24	0.4000	15	Yale	4	16	0.2667
6	KEMRI	8	24	0.4000	16	UB	5	16	0.2667
7	UW	4	23	0.3833	17	UoD	4	16	0.2667
8	MU	3	21	0.3500	18	BASMU	5	16	0.2667
9	MTRH	9	20	0.3333	19	I-TECH	5	15	0.2500
10	UON	3	18	0.3000	20	EGPAF	5	14	0.2333

Table 7 shows the ranked closeness centrality scores for organisations found to be active within the HIS technology space. Foreign not-for-profit organisations and foreign universities made up the majority of the top 20 organisations as ranked by closeness centrality. These organisations can be viewed to be the ones most proximal to new knowledge or information irrespective of where it is generated within the whole network.

Table 7: Top 20 health information systems organisations ranked according to closeness centrality in descending order. Abbreviations are provided for in Appendix 1

Rank	Abbreviations	Category	Closeness	Rank	Abbreviations	Category	Closeness
1	MOH	1	0.6316	11	UON	3	0.4651
2	IU	4	0.5263	12	MTRH	9	0.4615
3	AMPATH	6	0.5217	13	VA HSR&D	2	0.4615
4	RII	5	0.5217	14	CU	4	0.4615
5	KEMRI	8	0.5128	15	JAICA	5	0.4615
6	UW	4	0.4959	16	UT	4	0.4615
7	USAID	5	0.4800	17	MRHC	9	0.4615
8	I-TECH	5	0.4724	18	Yale	4	0.4615
9	EGPAF	5	0.4688	19	UB	5	0.4615
10	MU	3	0.4651	20	UoD	4	0.4615

Table 8 shows the ranked betweenness centrality of organisations active within the network. The MOH was had the highest closeness centrality score. There were only 13 organisations which had recordable betweenness score with foreign not-for-profit organisations, local universities and foreign universities making up the bulk of these. These organisations are therefore more likely to receive information and knowledge before any other organisations therefore have a greater opportunity to affect how information flows along the entire network.

Table 8: Top 20 health information systems organisations ranked according to betweenness centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Abbreviations	Category	Betweenness	Rank	Abbreviations	Category	Betweenness
1	MOH	1	0.4136	8	RII	5	0.0273
2	KEMRI	8	0.1838	9	UW	4	0.0267
3	USAID	5	0.0732	10	MU	3	0.0099
4	IU	4	0.0468	11	UON	3	0.0051
5	I-TECH	5	0.0317	12	EGPAF	5	0.0018
6	CDC-USA	7	0.0292	13	SU	3	0.0017
7	AMPATH	6	0.0273	14	MTRH	9	0.0000

4.1.3. Telemedicine publication network

Fifteen organisations were identified as active in telemedicine from the review of literature. Local hospitals and foreign based universities made up the bulk of the active organisations. Seven of the organisations identified were Kenyan, 6 from the Americas, 1 from other African countries and 1 from the European region.

This network comprised of four distinct components, one of which is a single component and another which comprises two nodes. had a network density of 0.333 with 70 ties. There was an almost equal representation of local and foreign nodes in the network with two distinct sub-networks as visualised in Table 9. The ranking of the organisations from the degree and closeness centrality scores were found to be identical thus allowing for the results to be presented together in. The organisations ranked most highly included foreign universities, foreign not-for-profit organisations, and local hospitals. It was not possible to calculate the betweenness centrality for this network structure due the disjointed nature of the network.

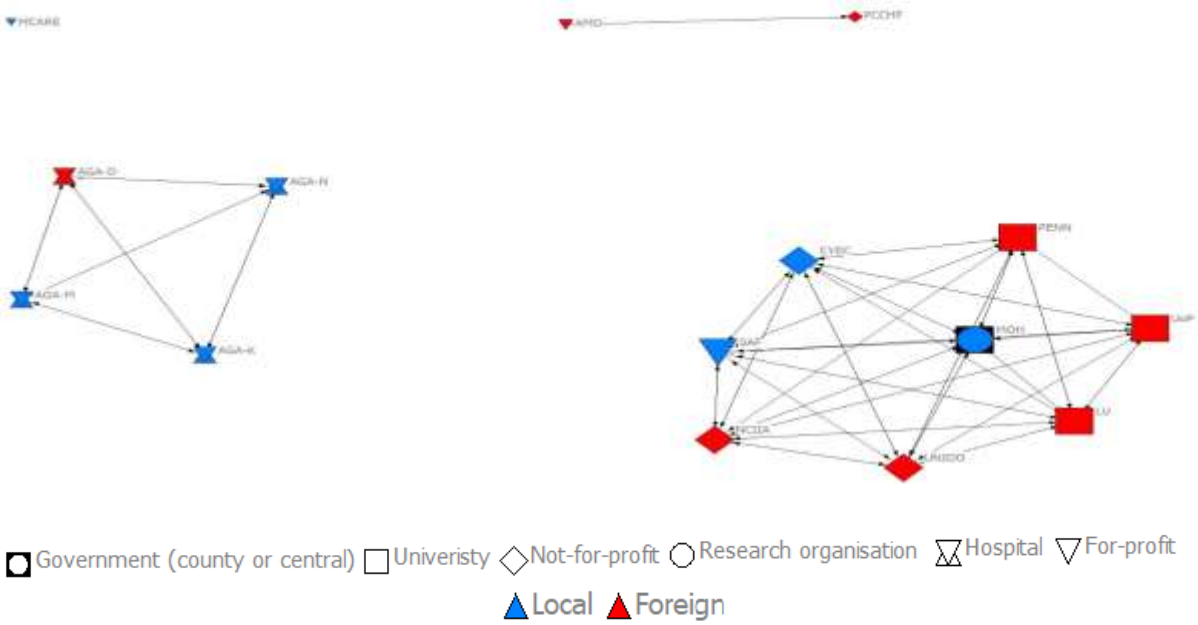

Figure 5: The telemedicine publication network from 2001 to March 2018. Nodes have been scaled to degree and the edges have been weighted to the number of times organisations have collaborated together. Abbreviations are provided in Appendix 1.

Table 9: Top 15 telemedicine organisations ranked in descending order according to degree and closeness centrality. Abbreviations are provided in Appendix 1.

Rank	Abbreviations	Category	Degree	Closeness
1	UoP	4	0.5000	0.5600
2	MOH	1	0.5000	0.5600
3	SAF	13	0.5000	0.5600
4	PENN	4	0.5000	0.5600
5	UNIDO	5	0.5000	0.6667
6	NCIIA	5	0.5000	0.6667
7	CYEC	6	0.5000	0.6667
8	LU	4	0.5000	0.6667
9	AGA-N	9	0.2143	0.6667
10	AGA-M	9	0.2143	0.6667
11	AGA-D	9	0.2143	0.6667
12	AGA-K	9	0.2143	0.6667
13	AMD	12	0.0714	0.5000
14	PCCHF	5	0.0714	0.5185
15	MCARE	13	0.0000	0.5185

4.1.4. Publication network for other forms of eHealth

Forty organisations not fitting into the other eHealth categories were identified as active collaborators. Universities and not-for-profit organisations made up the bulk of the organisations identified. When assessed by regions the only regions represented were Kenya (21) and North America. Figure 6 shows the network of actors whose areas of activity were found to be clearly distinct from the three other types of eHealth (mHealth, health information systems and telemedicine). The network density was found to be 0.1372. There were isolated organisations that were not found to have collaborating partners but were active within this eHealth space. This is presented on the left-hand side of Figure 6 as disconnected nodes.

Table 10 shows the top 20 ranked degree centrality scores for nodes within the network. Moi university had the highest degree centrality score (0.3590). It was followed by Kijani consultancy, Brown University, AMPATH and InStedd. Of the top 20 nodes, foreign, local not-for-profit organisations and foreign universities made up the bulk of the organisations.

Table 11 shows the ranked closeness centrality scores for some of the organisations within the network. Of the top 20, Moi university and Kijani consultancy had the highest scores for closeness centrality, with foreign universities and foreign not-for-profit organisations making up the bulk of the organisations.

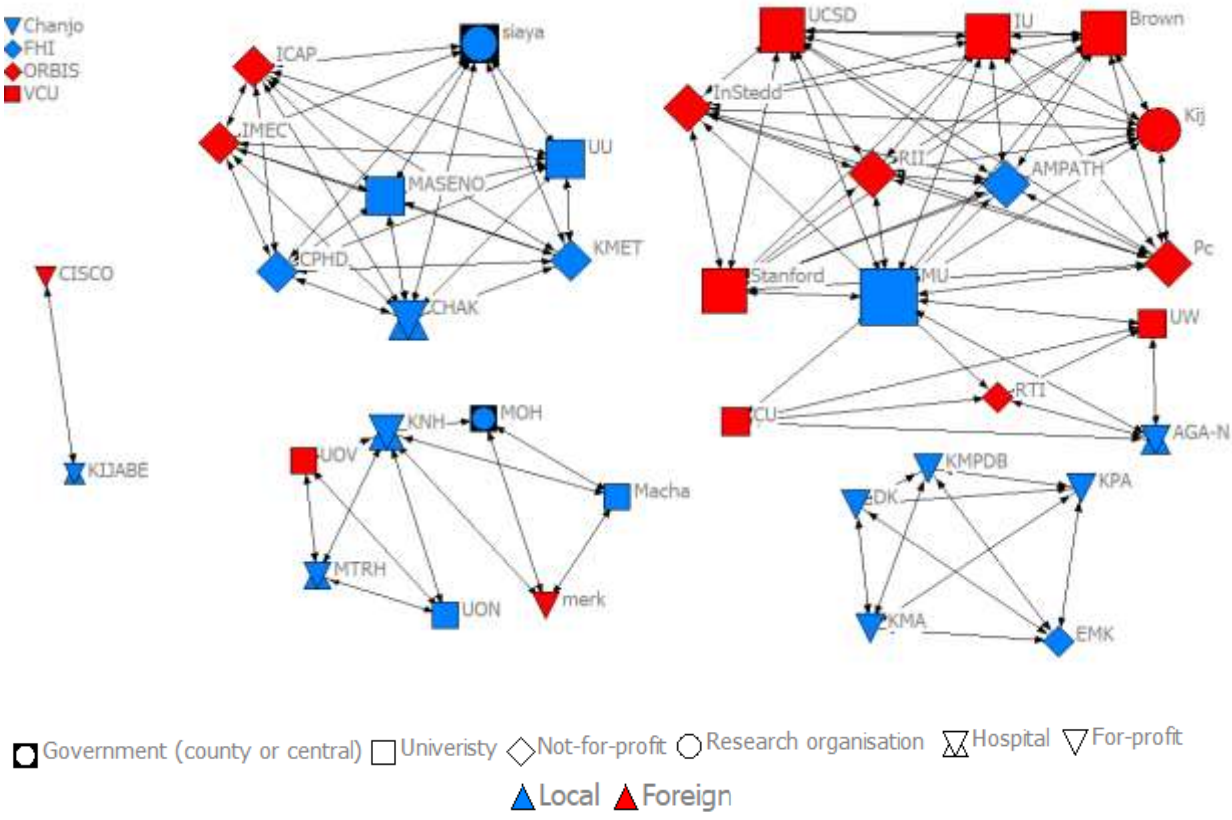

Figure 6: The publication network for other forms of eHealth from 2001 to March 2018. Nodes have been scaled to degree centrality and the edges have been weighted to the number of times organisations have collaborated. Abbreviations are provided for in Appendix 1.

Table 10: Top 20 organisations ranked according to degree centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Abbreviation	Category	Degree	Rank	Abbreviation	Category	Degree
1	MU	3	0.3590	11	MASENO	3	0.1795
2	Kijani	7	0.2308	12	CHAK	9	0.1795
3	Brown	4	0.2308	13	Siaya County	1	0.1795
4	AMPATH	6	0.2308	14	IMEC	5	0.1795
5	InStedd	5	0.2308	15	UU	3	0.1795
6	RII	5	0.2308	16	KMET	6	0.1795
7	Pc	5	0.2308	17	ICAP	5	0.1795
8	Stanford	4	0.2308	18	CPHD	6	0.1795
9	UCSD	4	0.2308	19	KNH	9	0.1538
10	IU	4	0.2308	20	AGA-N	9	0.1282

Table 11: Top 20 organisations ranked according to closeness centrality in descending order. Abbreviations are provided in Appendix 1.

Rank	Abbreviation	Category	Closeness	Rank	Abbreviation	Category	Closeness
1	MU	3	0.4286	11	CU	4	0.3900
2	Kijani	7	0.4105	12	UW	4	0.3900
3	Brown	4	0.4105	13	AGA-N	9	0.3900
4	AMPATH	6	0.4105	14	RTI	5	0.3900
5	InStedd	5	0.4105	15	MASENO	3	0.3786
6	RII	5	0.4105	16	CHAK	9	0.3786
7	Pc	5	0.4105	17	Siaya	1	0.3786
8	Stanford	4	0.4105	18	IMEC	5	0.3786
9	UCSD	4	0.4105	19	UU	3	0.3786
10	IU	4	0.4105	20	KMET	6	0.3786

The betweenness centrality could only be computed for two nodes as a result of the disjointed nature of the network. The two nodes represented one local university - Moi University - which had a score of 0.0486 and one local hospital, Kenyatta National Hospital which had a betweenness centrality score of 0.0121.

4.1.5. Summary of results from publication network

Based on the publication data, the mHealth network was identified as having the largest number of collaborating organisations. Kenyan and North American based organisations were found to be the most active for most networks with foreign universities and foreign not-for-profit organisations featuring significantly. All networks were found to have low cohesion measures as indicated by the low network density scores obtained. This means that actors in the publication networks were not closely connected to each other regardless of the area of eHealth with the health information systems network being having the highest cohesion. The MOH had participated in implementation in all four of the strategic areas and had many ties with many different organisations.

4.2. Analysis of data obtained from interviews

Active organisations within the eHealth implementation space were identified from the social network analysis. Individual participants involved directly in the eHealth implementation work were then identified through phone calls to the organisations or face to face networking during technical conferences. Emails were then sent out to six prospective participants requesting their participation in the study. Snowball sampling was done after conducting the first round of interviews; this allowed for 12 other participants dealing with eHealth implementation within their respective organisations to be identified. Eighteen emails invitations for participation in the study were sent out in total. Twelve positive responses were received.

A total of 12 interviews were conducted with an average duration of 48 minutes per interview. The participant organisations included the MOH, local for-profit and not-for-profit entities involved in the implementation of eHealth, government research organisations, academia among others. Most of the participants worked within the Health Information

system implementation space as shown in Figure 8 where informatics was the most popular area of specialization.

The results are presented in two sub-sections; one dealing with the characterisation of stakeholders and data obtained from the analysis of the interview-based network and the other section dealing with the results of the thematic analysis of the semi-structured interviews.

4.2.1. Interview-based eHealth network

Ninety-five organisations were identified in the interview-based network. Foreign-based universities and not-for-profit organisations were the most common with foreign organisations making up almost half of all organisations in this network as shown in Table 12. Most organisations active within the sector were found to be based in either Kenya or the United States of America as shown in Table 13.

Table 12: Organisations by type in the interview-based networks

Abbreviation	Organisation type	Number of organisations
FNPO	Foreign not-for-profit organisation	21
FU	Foreign University	15
G	Government (county or central)	13
LU	Local University (within Kenya)	9
LNPO	Local not-for-profit organisation	9
LPC	Local for-profit organisation	9
LH	Local hospital	7
IPC	International for-profit organisation	7
IG	International government	2
IRO	International research organisation	2
LRO	Local research organisation	1
IH	International Hospital	0

Table 13: Distribution of organisations sorted by geographical region of origin in the network as identified from the analysis of the semi-structured interviews.

Region	Number of organisations
Kenya	48
North America	28
Europe	10
Africa excluding Kenya	6
Asia-Pacific	3

Figure 7 shows the collaborative network for eHealth in Kenya as identified from the semi-structured interviews. Health information systems was the most common type of technology implemented.

The eHealth network had a network density 0.0618 which indicates that most actors in the network were not closely connected to each other.

Among the collaborating organisations, there was a more even distribution in the numbers of foreign organisations and local organisations identified as compared to the publication networks where there were more foreign organisations. The MOH, UON and Moi University are locally based organisations that were found to have been involved in many projects and having many collaborating partners.

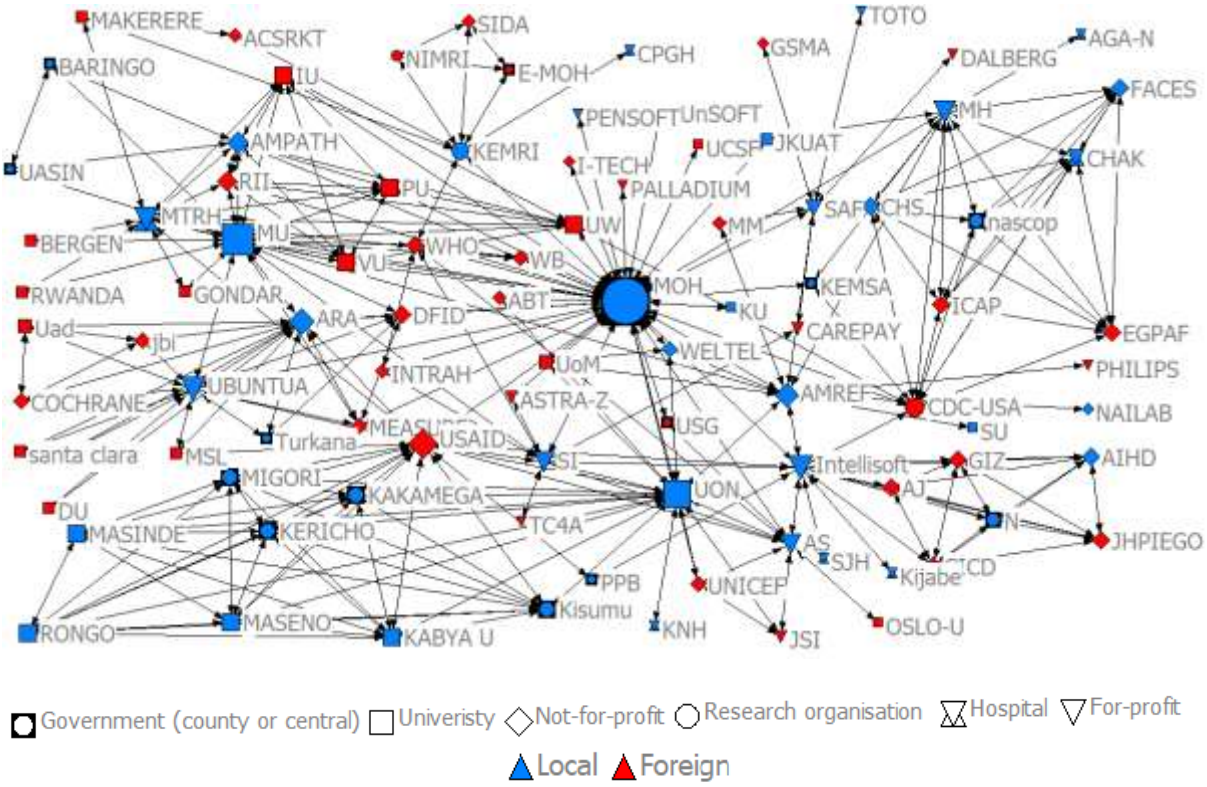

Figure 7: The interview-based network. Nodes have been scaled to degree centrality and the edges have been weighted to the number of times organisations have collaborated together. Abbreviations are provided in Appendix 1.

Table 14 shows the top 20 organisations sorted from the largest to the smallest with regard to degree centrality. The MOH had the highest degree centrality (0.3491) followed by Moi University, University of Nairobi, and USAID. This can be interpreted as the MOH being the node with the largest capacity to transmit information to all other nodes within the network. Of the top 20, local for-profit organisations, local universities, local not-for-profit organisations made up the bulk of the organisations.

Table 14: Top 20 eHealth organisations based on interviews, ranked in descending order according to degree centrality scores. Abbreviations are provided in Appendix 1.

Rank	Abbreviations	Category	Degree	Rank	Abbreviations	Category	Degree
1	MOH	1	0.8191	11	CDC-USA	7	0.1596
2	MU	3	0.2979	12	WHO	5	0.1489
3	UON	3	0.2553	13	AS	13	0.1489
4	USAID	5	0.2553	14	AMREF	6	0.1383
5	ARA	6	0.2340	15	AMPATH	6	0.1383
6	UBUNTUA	13	0.2234	16	UW	4	0.0957
7	SI	13	0.2128	17	KEMRI	8	0.0957
8	MTRH	9	0.1809	18	MASENO	3	0.0957
9	Intellisoft	13	0.1702	19	Kisumu	1	0.0957
10	MH	13	0.1596	20	KABYA U	3	0.0957

Table 15 shows the highest ranked betweenness centrality of organisations active within this network. The MOH ranks as the organisation with the highest betweenness centrality score (0.5620). This means they have the greatest influence on how information flows through the network. Of the top 20 highest ranked actors, local for-profit organisations, foreign not-for-profit organisations and local not-for-profit organisations made up the bulk of the organisations.

Table 15: Top 20 eHealth organisations based on interviews, ranked in descending order according to betweenness centrality scores. Abbreviations are provided for in Appendix 1.

Rank	Abbreviations	Category	Betweenness	Rank	Abbreviations	Category	Betweenness
1	MOH	1	0.5620	11	SAF	13	0.0728
2	Intellisoft	13	0.1765	12	CDC	7	0.0679
3	USAID	5	0.1341	13	SI	13	0.0509
4	AMREF	6	0.1108	14	MTRH	9	0.0479
5	KEMRI	8	0.1063	15	AS	13	0.0364
6	MU	3	0.0967	16	AMPATH	6	0.0111
7	UON	3	0.0951	17	WHO	5	0.0095
8	MH	13	0.0771	18	UW	4	0.0068
9	ARA	6	0.0743	19	DFID	5	0.0051
10	UBUNTU-A	13	0.0743	20	Makerere	4	0.0042

Table 16 presents the actors having the highest closeness centrality. The MOH is the highest ranked organisation according to closeness centrality score. Of the top 20 organisations, local for-profit organisations, foreign not-for-profit organisations and local not-for-profit organisations made up the bulk of the organisations identified. These organisations can be said to be closest to new knowledge irrespective of where in the network this knowledge is generated.

Table 16: Top 20 eHealth organisations in the interview-based network, ranked in descending order according to closeness centrality scores. Abbreviations are provided for in Appendix 1.

Rank	Abbreviations	Category	Closeness	Rank	Abbreviations	Category	Closeness
1	MOH	1	0.6309	11	MTRH	9	0.4434
2	USAID	5	0.4921	12	CDC-USA	7	0.4352
3	AMREF	6	0.4896	13	MH	13	0.4273
4	Intellisoft	13	0.4796	14	WHO	5	0.4253
5	MU	3	0.4653	15	UW	4	0.4234
6	SI	13	0.4608	16	DFID	5	0.4196
7	UON	3	0.4585	17	UoM	4	0.4178
8	ARA	6	0.4541	18	WELTEL	6	0.4178
9	UBUNTUA	13	0.4541	19	MEASURE	5	0.4178
10	AS	13	0.4476	20	AMPATH	6	0.4141

4.3. Thematic analysis of interviews

The 12 participants interviewed were invited to speak freely about their experiences working on implementing different eHealth projects. Figure 8 shows the fields in which the participants were active. The average duration that participants had been active in the eHealth space in Kenya was 12.3 years.

Figure 8: Word cloud representation of different areas of specialization for the interview participants

The Interview transcripts were analysed, guided by the research question based on three areas of interest, namely participant knowledge, the nature of the network, and the challenges and opportunities in the network. Table 17 shows the final codes and emergent themes that are discussed in the next section.

Table 17: Areas of interest, themes and subthemes identified from the thematic analysis of the semi-structured interviews.

Areas of interest	Themes	Subthemes
Participant knowledge	Knowledge generation	Source of knowledge
		Outcomes of knowledge generation
	Knowledge translation	Channels for transfer
Nature of the network	Capacity	Technical
		Implementation
		Research
	Funding	
Challenges and Opportunities	Challenges	
	Opportunities	Collaboration
		Strengthening communities of practice
		Early engagement of end users

4.3.1. Participant knowledge

Two themes that emerged under this area addressed how knowledge, in whatever form, is brought into the network and how it is handled to enable it to spread within the network.

- Knowledge generation

Tacit knowledge was the most common form of knowledge generated within this network as identified from analysis of the interviews. Tacit knowledge refers to knowledge participants generate by learning or from experience. It has been described as a form of knowledge that is difficult to transmit in writing or speech; transmission and usually requires more effort, at times close interactions between participants and even hands-on experience (Reagans & McEvily, 2003). There were fewer references to explicit knowledge generation within the network. Explicit knowledge refers to knowledge that can be readily be acquired, stored and spread to others within the network (Su, Yang & Zhang, 2017). A common example of explicit

knowledge referenced in the interviews was when one participant described going through publications, newspaper articles and other forms of grey literature as being an important part of the process of identifying partners to work with in the network.

- Sources of knowledge

A subtheme that emerged addressed how the participants gained knowledge that allowed them to work as implementers of different eHealth technologies or different activities they undertook that resulted in creating new knowledge. Technical working groups were described as an effective way to generate explicit knowledge. For tacit knowledge this was through activities like going back to tertiary education institutions to follow a master's or PhD programme, conducting research in the area or by directly working on the development and implementation of different projects.

- Outcomes of knowledge generation

Another subtheme that emerged addressed the consequences of knowledge generation. An example of this for tacit knowledge can be seen in a scenario described by one participant where working pro bono on a project later created an employment opportunity in another organisation that allowed them to earn a living and even provided an opportunity for them to further their education. *"It was my interest, not what I was paid for, and eventually I was transformed into being a trainer on the system to utilise it to its highest capacity…. so, I was promoted to become a staff trainer for the entire university and then 2 years later… recruited me into the computer career institute whose aim was to help staff being recruited get through this training that I was doing, and I went to start the programme."*

One participant described how, after they held focus groups with their intended end users, they gained insights that helped them design the mHealth solution in a way that was culturally and socially acceptable thus aiding the uptake of the solution and contributing to the overall success of the project. *"It was at the time around 2005 when free access to ARVS were being rolled… We decided to hold a focus group with our intended end users as part of the development phase and they told us… 'we don't want reminders. I know am meant to take medication…' We asked them for suggestions, and they agreed that from the health facility we send a text message to the patient asking them how you are. From their end, due to*

confidentiality… they expressed clearly that they did not want messages on HIV on [their] phone… So [these] are some of the things I learnt when designing your solution remembering to be user centred… if we had not done our focus group discussions, we would not have known what they wanted in specifics like the duration of text messages…"

4.3.1.1. Knowledge translation

Translation of knowledge refers to how knowledge generated can be packaged in a form that is accessible to others for example in terms of development of products with commercial value or conversion into policies (van de Burgwal, van der Waal & Claassen, 2018).

Generation of explicit knowledge was a common consequence of tacit knowledge generation and identified as important. An example from the interviews was the publication of research papers with one user using the expression *"All you can do is publish the experience"* as they described a project that failed due to poor end user engagement prior to implementation despite attracting funding and human resource support. Another participant described that by working on the development of a health information system that had interoperability at its centre, they gained valuable experience that allowed them to engage government and other stakeholders in the development of interoperability frameworks thereby converting the tacit knowledge they had gained into explicit knowledge that could be accessible to many in the network.

A common method used for packaging tacit knowledge for utilisation by others in the network, was the creation of consultancy companies that ended up providing much needed capacity to create regulations and guidelines like the Kenya eHealth policy and producing journal publications. They said the following *"We have been involved in the interoperability by helping MOH define eHEALTH interoperability policies and strategies and to rejuvenate the various stakeholders into a technical working group."*

Two participants described activities that created solutions that have been patented and are commercially available. This was described as a labour and cost intensive exercise *"We engaged…who helped us to develop financial models on how to make this sustainable. We also engaged with…who sent us students from…who interviewed public and private sector and gave us an inside report on the state of digital health that helped us understand how to price*

and penetrate the market. From this we were able to show…can be sold to third parties and that there was a lot of demand."

Another participant described a situation where knowledge generated during the design phase of a project was packaged and converted into a successful mHealth application that was later converted into a not-for-profit organisation that was eventually able to conduct two randomised controlled trials that have since been published.

An example of explicit knowledge being converted from one form to another was seen when one participant described how their business model has been converted into a case study published in a reputable international publication. Both explicit and tacit knowledge was also translated into teaching curricula available through local academic organisations that are used to increase capacity within the sector.

Another subtheme that emerged addressed channels used to spread the knowledge in the course of knowledge translation. The main activities referenced were the dissemination and acquisition of knowledge through conferences, journals, e-learning platforms, community of practice online groups and websites. One participant said *"Currently the best way to get information on digital health in Kenya is through a KEHIA (Kenya Health Informatics Association) email list. It is run locally… It has a lot of content about what is happening in eHealth in Kenya and globally."* There was also reference to a "HIS interagency coordinating committee" whose function is *"is important in bringing together stakeholders so that they learn what the government priorities are and what gaps have been identified and how to address these,"* according to one participant.

An example for tacit knowledge can be seen when one participant described a current project where an organisation that had generated knowledge around the implementation of projects was passing it on to other organisations within the same sector *"working with other universities located where implementation of projects is being built enables us to provide direct support. This is by working with local universities to build their capacity to train the peripheral organisations."* Another example was the use of Whatsapp groups that allowed implementing partners on the ground to raise any issues with teams based in the larger cities so that they could be addressed in a timely manner. One participant described this as an efficient way to work with partners to ensure technical problems are quickly solved. They said

"After training we create Whatsapp groups with their teams so that in the implementations they can post any challenges or frustrations, so we support them. Most of the facilities' breakdowns are knowledge-based maybe due to a breakdown in knowledge transfer. Within our teams we have roles assigned to support each partner. So, with all these different groups we have our techies embedded and within the techies we have one responsible for each team and figuring out who is to solve that. They also know who to call. We found this works better because you get to learn the problems of the ground rapidly which provides uninterrupted service delivery."

Quick coding sprints (that usually last one month and have programmers aiming to achieve specific objectives and hand them in for review) (Herden et al., 2014) and hackathons (usually last a day and have different stakeholders involved in software development working together intensively) (Halvari et al., 2019) have also been used to help spread knowledge to others in the network. Internships were also a common method described, especially in the consultancy and software development firms actively engaged in developing and implementing eHealth solutions within the country.

Several participants bemoaned situations where tacit knowledge generated is not utilised within the network due to a lack of evaluation of projects. One participant described this by saying *"…eHealth is a little bit interesting, as some people will come in with fully developed projects and try to deploy [a project] without knowing whether it will work for this group and after the project ends you do not get to see any feedback on how it worked."*

4.3.2. Nature of the network

This section focusses on references made to networks formed by the stakeholders while also highlighting some of the reasons that brought them together. Increasing capacity and funding patterns were identified as common themes that emerged.

4.3.2.1. Capacity

Participants referred to instances or reasons for leveraging the network to increase their own capacity. Different subthemes emerged depending on whether participants used their network relations to increase their technical capacity for example software development

capacity, their research capacity or implementation capacity. Seeking technical capacity was found to be the most referenced, followed by seeking implementation partners and finally increasing their research capacity.

- Technical capacity

Many participants referred to seeking or proving technical capacity as one of the reasons they came together to work on a project. One of the stakeholders in academia described a project that was set up for this reason. *"We will have this project…which is basically providing technical assistance…as there is a lack of technical and software development and software systems, network competence, so through this project we are able to provide these skills."*

There were several advantages identified in leveraging the network for technical assistance. One participant cited the coming together of different organisations to increase capacity as a means of increasing sustainability of their organisation. *"If we have a large project beyond our capacity in terms of number and skill sets, we recruit consultants. That's why we work with organisations like the…It helps the organisation to stay lean."* Another advantage of seeking technical assistance from organisations like universities was that it provided an opportunity to provide exposure to industry for both lecturers and students within such organisations. *"…we are a small organisation so we have to link up with the large organisations ...the reason we do this is for example if we need software developers is to go to this universities that have computer science courses...We also know that universities need to expose their students to the industry so what we do is allow for attachments where every season we have students who are on attachments."*

One participant described seeking out locally available technical capacity as more efficient and beneficial to the eHealth in the long term. *"…one of the reasons for some solutions taking long is because of the wide physical distances between the stakeholders for example if some developers are based out of the country… this creates a situation where small issues that could have taken a few hours to solve can take several days as maybe one team is asleep while the others need input. But now we are looking for local capacity to make the process more efficient. With regard to sustainability, if a solution works, once we implement the solution and the foreign researchers and their development network leave, will the local county be able to maintain the international network in case an issue arises?"*

- Implementation capacity

Increasing an organisation's ability to implement projects was also identified as a reason for collaboration: *"…we started collaborations again with…because they have reach in all the 47 counties and also to other countries..."* or *"we are not the guys in the facilities even though we have developed the systems… there are people that are funded to support the facilities… we implement through the partners… they have 62 facilities"*

Another participant said *"working with other universities located where implementation of projects is being built, enables us to provide direct support. This is by working with local universities to build their capacity to train the peripheral organisations."*

- Research capacity

Organisations without research departments were able to conduct research to guide the project implementation process by working with organisations with this capacity. "*We also have students from…working on their PhDs focusing on our systems that we build thereby supplementing our staff."* This was however not as common a form of capacity being sought as technical and implementation capacity.

4.3.2.2. Funding

Another theme that emerged as important in guiding the network structure was funding. Participants implied that most of the work in their sector was heavily dependent on foreign funding. *"It is heavily donor dependent like in the… county work we have a service contract funded by….working with the head of NCDs in the county"* Another said *"…that is the starting point of my interaction with…as the US organisations basically help with health systems strengthening by providing technical support and financing with the direction being provided by the strategies of the MOH."*

Funding not only contributed to what sort of projects were being implemented but was also crucial to the survival and existence of organisations working in this space. One participant said the following as they described how their organisation has grown over time; *"…the growth or the scale up has been really opportunistic, guided by funding opportunities but also biased by our settings of interest…"* Another said the following *"90% of the research here at*

[organisation] is funded by foreigners, and when research is funded by foreigners all the data collected goes back to the donor countries."

Funding also had an effect on how organisations would organise themselves within the network. Organisations that received funding were central to the project implementation process as they would be the ones to enrol other organisations or stakeholders to aid in their execution of tasks. One participant described the following situation as they explained the genesis of their involvement in a project; *"…the university was subcontracted by an NGO called…that created a project called …this got us more into engagement with the ministry and later going to the implementation spaces and this really opened up the space…"* Another also described a situation where smaller organisations come together in order to qualify for grant financing. *"…if you apply for a grant when you are very small, you won't get funding by yourself. So, you create a network that will allow you to compete for funding in a more complementary fashion.*

Funding also provided an incentive for information exchange with one participant describing the importance of being part of the available online information exchange platforms like the KEHIA email list by saying that it *"…disseminates a lot of information in case someone wants to know what is happening about events and funding."*

4.3.3. Challenges and Opportunities

This section presents the challenges and opportunities related to knowledge flow in the network.

4.3.3.1. Challenges

Access to information was described as a challenge faced by stakeholders in the sector with one participant stating *"…it is dependent on informal communications like calls and random meet ups. It feels like luck at times, being at the right place at the right time and talking to the right person."*

Another participant described the process of finding partners who can provide assistance or finding potential employees to add to a team as being tedious, requiring one to spend extra effort to learn what is happening in the sector. They said the following; *"The way it works is*

that you have to participate actively within their conferences, seminars and research gathering. You have to be proactively interacting with academia. …there are no marketing platforms available; you have to be involved in teaching and stuff so people get to know about the company and that's how [a client] will come to them. Look for organisations by scanning people who are young and follow them when they are young. Like start up conferences…So we will go and make sure that people know about [the organisation] and that we know about them. EHealth workshops help identify organisations that can help."

Knowledge flow, with regard to health system needs, between the end users (i.e. beneficiaries and operators of eHealth solutions) and the implementers (i.e. developers, experts or consultants) was also found to be wanting with several participants associating it with poor project uptake. One participant suggested this as a reason for project failure; *"We went and met the team leader of eHealth (functional beneficiary) …hospital, she listened for 2.5 hours and told us point blank, 'I like you ICT people (developers), but you have created your own problems and solved them yourselves. Whatever you are telling us you are not solving our problems. Come we show you our needs and help us solve them.'"* Another participant opined that poor scaling of projects can be attributed to poor knowledge exchange among the implementers themselves by saying *"…there is the pilotitis issue of running many different pilots just to see what projects will be scaled yet Kenya has many innovation hubs…"*

Low research output within the sector due low funding for research, long proposal approval processes and reduced capacity to conduct research contributed to the poor access to knowledge according to several participants. Even where research was conducted it was described as a process that either took very long to complete or was not accessible to those who need it*: "…MOH is active and counties are not as active especially because most counties are still experimenting with devolution and only now starting to set up research offices. With a research office you have responsibility of the knowledge generated within a county. Students will do work in universities, but it is not linked and reported back to counties as there is no ownership and support of research to solve their own issues. The large research bodies can publish in many international journals that do not ever reach the counties…."*

The eHealth landscape was described as still being in its early development phase. The community of practice in terms of technical, implementation and research capacity is small

with few formal channels of knowledge transfer and several divergent definitions of concepts like interoperability.

Human factors like poor attitudes towards technology, bias, competition and distrust were said to shape the knowledge sharing culture between stakeholders contributing to the low access and exchange of information between stakeholders. One interviewer described it this way: *"Unfortunately organisations within the eHealth network tend to be guarded when it comes to some information... The sector is not quite open to diffusion of information because we do not know when information will be used as a market advantage against you when you share it. So, information is heavily controlled within the sector."*

4.3.3.2. Opportunities

Collaboration between local organisations implementing projects at the devolved government units and universities that have greater capacity and experience was described as having shown potential to increase the knowledge flow within the network. One participant described this collaboration as having improved the capacity of the counties to monitor and evaluate projects that have been implemented at this level and to develop their own projects. Collaboration also provided new channels for donor agencies to directly fund projects at the level of local organisations: *"By building those relationships to an extent that the county comes to the local university for other things like monitoring and evaluation, systems evaluation and even moving to other areas to do with implementation…some counties have started to use it to aid the development of data repositories and we are starting to see it spreading to other counties... Some have requested for disease registries like for sickle cell and so on and so forth. The donors are really impressed by it to a point we are even looking to roll it out to other countries like Lesotho, Swaziland and Nigeria and Ethiopia. It seems donors have been looking for another way to reach the counties… how to make other public institutions interact with government in a sustainable manner by increasing local capacity as opposed to central government capacity. It is now even moving into other things, like working with local private organisations in counties to foster a form of working relationships because the current model, which is one of a foreign-based donor-funded NGOs coming in to implement projects, then at the end of the project they close up and leave and no capacity is*

left on the ground, is not creating many sustainable projects."

Early end user engagement was another approach that was highlighted as having the chance to increase the knowledge flow between stakeholders in the network. By engaging end users this way, implementers have been able to improve ownership of projects at ground level and even modify attitudes towards eHealth.

Blended training modules, hackathons, boot camps, and master's degree programmes with theoretical and practical modules for development and implementation of projects were some of the successful solutions that were used to attempt to increase the human capacity within the field of informatics, which is useful in eHealth.

Creating strong communities of practice was suggested as sure way to improve knowledge flow within the sector. Creating formal channels of knowledge exchange, strengthening implementer associations like KEHIA and providing financial, legal and human resource capacity to protect intellectual property were some of the solutions suggested to increase trust between stakeholders. By working together, stakeholders could better engage with law makers and funders and therefore improve on the ability of the network to regulate development and implementation activities. They would also be able to curate the varied curricula being used in human resource training.

Technical working groups, stakeholder meet-ups and regular conferences were also said to have been successful in the past in bringing players together to help update players in the sector. Other successful methods referenced were online chat platforms like Whatsapp groups and other online community of practice groups which allowed for knowledge gaps between stakeholders to be bridged by leveraging technical capacity from anywhere in the world. One participant described proper engagement in such communities as being more critical to successful implementation of the projects than the technology itself. *"For me the success …is less about the technology as it's not 100% perfect. Audits show there is room for improvements. It's more about the people driven by a sense of honesty and commitment to even share their own knowledge. You will engage with the guy who leads the terminology group - an expert within his own right ... always amazed at how he readily shares information other people would hold back. There is a culture of truly sharing."*

Encouraging knowledge translation practices like adding value to data at the point of collection by analysing it and presenting it in a format that can be utilised to inform decisions, converting successful implementations into case studies and creating business models that promote sustainability, were put forward as means of increasing the interaction and knowledge flow between stakeholders. The conversion of successful and failed projects into case studies was described as contributing to attracting skilled labour, investment, and support to the network. By packaging knowledge in innovative new forms for example like the formation of for-profit and not-for-profit organisations, stakeholders have been able to increase funds available in the network and therefore create employment opportunities that ultimately increase the community of practice. These benefits have not only been felt within the local public health sector but also within the other sectors in Kenya and other countries on the continent.

4.3.4. Summary of interview results

With regard to participant knowledge, the main themes that emerged had to do with how knowledge was generated within the network with the subthemes focusing on where the knowledge was obtained from and the outcome of the knowledge generation activities. Knowledge translation refers to how knowledge generated was handled and converted into a form that is available for utilisation by other stakeholders in the network. Tacit knowledge generated did not always result in knowledge translation through the network. There were more translation and transfer activities referenced than generation activities for explicit knowledge.

The network structure was guided by organisations coming together in order to increase their own implementation, research and technical capacity. The sector was described as donor dependent meaning that funding played a significant role in determining the network structure. Access to information, low research output, and human factors like negative attitudes towards technology were identified as some of the challenges faced in the sector. There were success stories that provided opportunities for improving knowledge flow moving forward, for example, the success of county government and university collaborations,

increased examples of end user engagement early in development improving ownership of projects, and the reported increase in blended training modules to increase capacity.

5. Discussion and Conclusion

5.1. Discussion

By using data from the review of literature and the qualitative interviews, the study sought to examine the diffusion of eHealth knowledge in the Kenyan public health sector by visualising the collaboration network structure and describing the flow of knowledge, its challenges, and the opportunities to improve it from the point of view of eHealth actors.

One limitation described in previous SNA studies, whose networks were generated from publications only, was that this approach was biased towards publication-oriented organisations like universities while leaving out other organisations like industry players (Chimhundu, de Jager & Douglas, 2015; de Jager, Chimhundu & Douglas, 2017). This study generated two networks: a publication and an interview-based network.

The two types of networks generated were found to have similar stakeholder composition. In the analysis of stakeholders by type, the study found that local and foreign-based government stakeholders, universities, for-profit and not-for-profit organisations, research organisations and hospitals were active within the eHealth implementation space in Kenya. Most of the organisations identified were based either in Kenya or North America for both networks generated. A similar picture is seen in other low to middle income countries where the following types of stakeholders were identified by Hyder et al. (2010): “beneficiaries, central government agencies, MOH, local governments, financiers, civil society organisations, and health governing boards, provider organisations, professional organisations and health workers, unions, suppliers”. One of the reasons that can be linked to also explain the

The publication and interview-based networks also showed similar network metrics. The MOH, USAID, Moi University and the University of Nairobi were found to be among organisations that had high degree centrality scores for the mHealth and health information systems publication-based network and the interview-based networks. Differences between the two networks were found when individual organisations were assessed. An example of this is that more local government agencies, other than the MOH, were identified in the interview-based networks than were identified from the publication-based network. There were also isolated instances where local for-profit companies had a low degree centrality

score in the publication networks but had a higher score in the interview-based networks. Findings from the interviews that show low research capacity as a challenge faced in the sector, would explain low publication rates, and as such certain organisations may not be present in publication-only networks.

Cohesion within the eHealth space was low, meaning most actors were not connected to each other; this was the case for both the publication networks and interview-based network. Networks with low cohesion scores have impeded knowledge flows (Wasserman & Faust, 1994; Vuori, Helander & Mäenpää, 2019). Protection of knowledge, and therefore prevention of knowledge flow, was attributed to concerns about maintaining a market advantage in the interviews.

Low network cohesion has also been associated with young networks where actors are not yet familiar with each other (Patterson et al., 2013). The interview analysis suggests that the eHealth development landscape in Kenya is in its early development phase, with low human capacity and few formal channels of knowledge transfer. When organisations are not familiar with each other this can be a hindrance to the creation of trust. There were also instances described in the interviews where trust had been fostered by stakeholders having worked together and with positive results; this resonates with the literature (Tiwari, 2015).

Interview analysis showed that poor flow of knowledge from the end users to the implementers during the development phase and back to the users after development was a challenge. Patient groups did not feature as stakeholders in the interviews. It is common for patient groups not to be viewed as stakeholders by other actors in the network, yet it is legally and socially appropriate for them to be part of the development process for technology that they will use voluntarily or involuntarily (Eysenbach, 2008, as referenced by van Limburg et al., 2011). This provides an example of an individual-level barrier to knowledge sharing within the network which is dependent on the behaviour and deeds of individuals who are involved in the network (Riege, 2005). The effects of such a barrier can have severe effects on project success. Several participants described their own experiences that showed end user engagement as critical for increasing uptake and ownership of eHealth projects with several describing the success or failure of projects as having been dependent on early end user engagement.

Another example of individual-level barriers identified was that knowledge shared was mainly explicit rather than tacit knowledge (Riege, 2005). This study found there were more references to tacit knowledge generation activities than there were for translation and transfer activities of such knowledge. For explicit knowledge, there was a predominance of transfer activities over generation activities, which could be linked to low levels of project evaluation. Several participants expressed concern that once projects end, researchers working with foreign organisations can leave with knowledge generated only being available through publication, leaving low capacity in the implementation space. This type of barrier presents a challenge to user access to and utilisation of knowledge.

Findings from the interview analysis showed that funding played an important role in how the network was structured. In the characterisation of stakeholders for publication networks, foreign-based universities and not-for-profit organisations made up the majority of the organisations present. The interviews showed that some of the funding for early project implementation came through the PEPFAR project or from USA-based donor agencies. Other studies examining the Kenya eHealth landscape have shown that when programmes rely on donor funding there are many different foreign and local organisations involved in the implementation of eHealth, creating a lack of ownership of projects by the MOH, which in turn leads to increased fragmentation and repetition (Njoroge et al., 2017). This has also been described in other African countries where it poses a challenge to the efficient management of the limited funds available (Sy, 2018). This is a network-specific barrier to knowledge transfer which may be exacerbated by the geographical distance between stakeholders active within the sector (Vuori, Helander & Mäenpää, 2019). The effect of this type of barrier was illustrated in the interviews, with one participant decrying the difficulty of coordinating the rectification of an acute problem during implementation, when the developers and implementers were on different continents. A study assessing the state eHealth in Senegal described a situation where due to a lack of communication and coordination, independently funded developers created systems that have already been developed by other stakeholders leading to duplication of projects (Sy, 2018). One suggestion given to solve this problem was for not-for-profit organisations to work together with the Ministry of Health to streamline approval of new projects so that it does not result in duplication (ibid). Such measures would,

however, be difficult in a network with low network cohesion due to the impeded flow of knowledge (Wasserman & Faust, 1994).

Regarding the centrality measures, the MOH had the highest degree, betweenness and closeness centrality scores. Findings from the interview analysis showed that funding contributed to how organisations interacted therefore influencing the structure of the network. Since most funding was programme-based, the MOH would be at the centre of the network. One participant asserted that nothing happens in the eHealth sector without the knowledge of the Ministry. The network metrics confirm that the MOH had the most connections with the most actors, was closest to all knowledge regardless of where in the network it was generated, and also had the largest opportunity to regulate information flows within the network. Organisational knowledge barriers within the MOH would therefore influence the whole network. Participants in the interview described a recent restructuring of the MOH in March of 2019. The benefits expected were that this would facilitate more efficient execution of its objectives especially in the implementation, monitoring and evaluation of digital heath in Kenya. Such measures have been described as important in preventing and dealing with organisation-based knowledge barriers (Riege, 2005).

Han, Koenig-Archibugi & Opsahl (2018) argue that high centrality in donor-funding driven networks, places governments in a good position where they can more efficiently receive diverse information from different sources creating the potential to select effective policies while being able to resist the untested ones. This is can be particularly advantageous early in the development phase of a technology field, especially since such knowledge can be more beneficial to the larger network than a direct transfer of money and material resources (Han, Koenig-Archibugi & Opsahl, 2018).

Such benefits have not been experienced by county governments. The few county government health units that were identified from both networks in this study had low degree, betweenness and closeness centrality scores. This means that they are not well connected to the other stakeholders, do not receive the available knowledge efficiently and have little influence on its control. Even though eHealth projects have been identified in most counties in Kenya, urbanised counties have been found to dominate (Njoroge et al., 2017). The interviews also pointed out that there was a challenge of capacity at county level to

manage the implementation of such projects. This shows that knowledge was not freely flowing through the network but was localised in some parts of the network. One participant noted that obtaining information in the network was dependent on luck and personal relationships. This is not unique to this network and has been described in other networks like the venture capital communities where such localised interactions lead to investments been made in regions that had direct ties with the investors (Singh, 2005 citing Sorenson & Stuart, 2001). This type of knowledge divide is a network-specific knowledge barrier and increases with a decrease in cohesion in a network (Singh, 2005; Vuori, Helander & Mäenpää, 2019).

Opportunities to improve knowledge flow were also identified in the study. By increasing the density of the collaboration networks, knowledge can flow more efficiently through the network (Singh, 2005). Most of the counties identified in the network analysis had ties connecting them to local universities that had higher centrality measures, such as the University of Nairobi and Moi University. Participants in the study described a project that had some success in increasing capacity at county government level through collaboration with universities in those counties. In linking academic stakeholders with other stakeholders active within the devolved administrative areas, there is an opportunity to improve knowledge flows to fringe organisational units in the country. This type of knowledge network fits into innovation models like the triple helix model where universities serve as potential links between actors that can facilitate more efficient flow of knowledge within the entire network (Mascarenhas, Ferreira & Marques, 2018). The process to facilitate the availability of knowledge generated to other actors within a network has, however, been described as complex, requiring coordination, correct knowledge management practices, and increased capacity and commitment by all actors (van de Burgwal, van der Waal & Claassen, 2018; Vuori, Helander & Mäenpää, 2019).

By combining quantitative social network analysis and qualitative analysis, the research project was able to identify, characterise and visualise the structure of the relationships between the stakeholders involved in the implementation of eHealth in the public sector (first and second objectives). By assessing collaboration between the stakeholders, barriers in knowledge flow were described and points of advantage and strength were identified (third

objective). The high centrality of the MOH is a point of strength. The importance of strengthening counties within the decentralized public health system has been highlighted.

5.2.Study limitations and suggestions for future work

Time and resource restrictions meant the range of organisations included in the qualitative interviews was limited, meaning that some views, especially that of organisations with low degree centrality scores, were not captured. Future research should include such organisations to aid in the development of solutions that are aligned to eHealth knowledge management strategies. Future work could also look more deeply into the barriers and opportunities to knowledge flow by assessing unsuccessful implementations and what has influenced them over time.

Greater understanding of barriers and opportunities could also serve to facilitate the development of more working partnerships with viable commercial models for eHealth implementation that can reduce the overdependence on donor funding for the successful implementation of eHealth projects in Kenya.

5.3.Conclusion

The eHealth network in Kenya is a young vibrant and growing one with varied participants working in different strategic areas of eHealth implementation. The network was shown to have many knowledge generation activities. The challenge was that much of the knowledge generated is in tacit form in a network with low cohesion. The formal channels that have been identified for knowledge transfer, have been shown in the literature to be better suited for transfer of explicit knowledge (Su, Yang & Zhang, 2017). eHealth knowledge diffusion is inhibited, creating a situation where stakeholders do not know what other stakeholders are doing are not able to include end user views into their development plans. If eHealth in Kenya is to achieve its function of assisting the health sector in improving the quality of life of Kenyans, there should be a conscious effort to develop more informal knowledge collaboration networks for the transfer of tacit knowledge. The high centrality of the MOH in all eHealth networks in Kenya provides an opportunity in that the MOH can readily play the

role of coordinating local and foreign stakeholders to build collaboration networks that capture and expand knowledge and capacity at county and national level.

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Appendix 1: Abbreviations of organisation names

MHealth		
Name of Organisation	**ABREVIATIONS**	**Organisation type and location**
AMPATH	AMPATH	Local not-for-profit
Colombia University	CU	Foreign university
University Of North Carolina	UNC	Foreign university
World Bank	WB	Foreign not-for-profit
George Town University	GU	Foreign university
University of California	UCSD	Foreign university
United States Agency for International Development	USAID	Foreign not-for-profit
Massachusetts General Hospital	MGH	Local hospital
Moi University	MU	Local university
Indiana University	IU	Foreign university
Massachusetts Institute of Technology	MIT	Foreign university
Harvard University	HU	Foreign university
Mbarara University of Science and Technology	MUST	Foreign university
University of Nairobi	UON	Local university
University of Manitoba	UOM	Foreign university
St. Pauls Hospital University of British Colombia	SPHUOBC	Foreign hospital
York University	YU	Foreign university
University of Washington	UW	Foreign university
McMaster University	MCMU	Foreign university
Public Health Agency of Canada	PHAC	Foreign research organisation
British Colombia Centre For Disease Control	BCCDC	Foreign research organisation
Karolinska Institute	KI	Foreign not-for-profit
AMREF Health Africa	AMREF	Local not-for-profit
University of British Colombia	UOBC	Foreign university
Weltel	WELTEL	Local not-for-profit
University of Ottawa	UOO	Foreign university

Fred Hutchinson Cancer Research Centre	FHRC	Foreign research organisation
Coptic Hospital	CH	Local hospital
Kenya Medical Research Institute	KEMRI	Local research organisation
University of Illinois	UOI	Foreign university
Kenyatta National Hospital	KNH	Local hospital
New York University	NYUCON	Foreign university
Jomo Kenyatta University of Agriculture and Technology	JKUAT	Local university
Washington Dept. Of Medicine	WDOM	Foreign government
Oxford University	OXFORD	Foreign university
Boston University	BU	Foreign university
Ministry of Health	MOH	Local government
Centre for Disease Control and Prevention	CDC-USA	Foreign research organisation
Moi Teaching and Referral Hospital	MTRH	Local hospital
RTI International	RTI	Foreign not-for-profit
Elizabeth Glaser Paediatric Aids Foundation	EGPAF	Foreign not-for-profit
John Hopkins University	JHU	Foreign university
Nordsjaellands Hospital	NOH	Foreign hospital
Roskilde Hospital	RH	Foreign hospital
Copenhagen University Hospital	CUH	Foreign hospital
University of Copenhagen	UOC	Foreign university
Management Science for Health	MSCH	Foreign not-for-profit
Novartis	NORVATIS	Foreign for-profit
Medicines for Malaria Venture	MMV	Foreign not-for-profit
Bill and Melinda Gates Foundation	BMDF	Foreign not-for-profit
University of California Irvine	UCI	Foreign university
FHI 360	FHI	Local not-for-profit
Red Cross America	RED CROSS	Foreign not-for-profit
United Nations Children's Fund	UNICEF	Foreign not-for-profit

Kit Royal Tropical Institute	KIT	Foreign for-profit
Med Africa	MEDA	Local for-profit
Freedom from Fistula Foundation	FFF	Foreign not-for-profit
Jamaa Mission Hospital	JMH	Local hospital
MPesa Foundation	MF	Local not-for-profit
ZMQ Development	ZMQ	Foreign not-for-profit
Humanist Institute for Cooperation with Developing Countries	HIVOS	Foreign not-for-profit
Knowledge Performance Now Health	KPN	Foreign for-profit
Liverpool Voluntary Counselling and Testing Health	LVCT	Local not-for-profit
Safaricom	SAF	Local for-profit
Non-Communicable Disease Alliance of Kenya	NCDAK	Local not-for-profit
Africa Institute for Health and Development	AIHD	Local not-for-profit
Danya International Inc.	DII	Foreign not-for-profit
Applied Innovations and Development Partners	AIDP	Foreign not-for-profit
Mbagathi District Hospital	MDH	Local hospital
University of Amsterdam	UOA	Foreign university
IAfya	IAFYA	Local for-profit
International Federation of Pharmaceutical Manufacturers and Associations	IFPMA	Foreign not-for-profit
Global Business Coalition On HIV, Tb, Malaria	GBC	Foreign not-for-profit
Sproxil	SPROXIL	Foreign for-profit
Kenya Pharmacy and Poisons Board	PPB	Local government
Orange Kenya	ORANGE	Local for-profit
M-Pedigree	M-PED	Local not-for-profit
NetHope Inc.	NETHOPE	Foreign not-for-profit
Sana Health	SANA	Foreign not-for-profit
World Vision International	WV	Foreign not-for-profit
UAP Insurance	UAP	Local for-profit
Changamka Micro health Limited	CML	Local for-profit
United Nations Development Programme	UNDP	Foreign not-for-profit
Britam Holdings Limited	BRITAM	Local for-profit

Intrahealth International	IH	Foreign not-for-profit
Kilifi County	KC	Local government
University of California San Francisco	UCSF	Foreign university
Kisumu Provincial Hospital	KPH	Local hospital
Pathfinder International	PI	Foreign not-for-profit
Visa Inc.	VISA	Foreign for-profit
Narok County Government	NCG	Local government
Vecna Charitable Trust	VCT	Foreign for-profit
University of Pennsylvania	UOP	Foreign university
Population Council	PC	Foreign not-for-profit
Innovative Support to Emergency Diseases and Disasters	INSTEDD	Foreign not-for-profit
Saving Lives at Birth	SLB	Foreign not-for-profit
Grand Challenges Canada	GCC	Foreign not-for-profit
United Nations High Commissioner for Refugees	UNHCR	Foreign not-for-profit
Regenstrief Institute Inc.	RII	Foreign not-for-profit
VA HSR AND D CENTRE On Implementing Evidence Based Medicine	VA HSR&D	Foreign not-for-profit
Open Data Kit Community	ODK	Foreign for-profit
Population Services International	PS	Foreign not-for-profit
Marie Stoppes International	MSK	Foreign not-for-profit
National Aids & STI Control Programme	NASCOP	Local government
Kenya Long Distance Drivers and Allied Workers Union	KLDAWU	Local not-for-profit
International Corridor for Migration	ICM	Local not-for-profit
North star Alliance	NA	Local for-profit
Medic Mobile	MM	Foreign not-for-profit
African Palliative Care Association	APCA	Foreign not-for-profit
Kisumu Medical and Education Trust	KMET	Local not-for-profit
Plan International	PLI	Foreign not-for-profit
FIO Cooperation	FN	Foreign for-profit
Japan International Cooperation Agency	JAICA	Foreign not-for-profit

Japan Science Technology Agency	JSTA	Foreign not-for-profit
Nagasaki University	NU	Foreign university
Kenya Medical Supplies Agency	KEMSA	Local government
London School of Tropical Medicine	LSTM	Foreign university
University of Utah	UU	Foreign university
University Of North Carolina	UNC	Foreign university
Brigham And Women Hospital	BWH	Foreign hospital
Pharm Access Foundation	PAF	Foreign not-for-profit
Jacaranda Health	JH	Local hospital
University of Leeds	UL	Foreign university
Mwapo Health Development Group	MWAPO	Local not-for-profit
Duke University	DU	Foreign university
University of Florida	UOFL	Foreign university
British Colombia Women's Hospital	BCWH	Foreign hospital
Human Science Research Council Sa	HSRCASA	Foreign not-for-profit
University of Witwatersrand	WITS	Foreign university
Path	PATH	Foreign not-for-profit
National University of Ireland	NUI	Foreign university
University of Heidelberg	UH	Foreign university
Health E-Net Limited	H-NET	Local for-profit
Strathmore University	SU	Local university
Burnet Institute	BI	Foreign research organisation
International Centre for Reproductive Health	ICRH	Foreign not-for-profit
Ghent University	GHENT	Foreign university
Latrobe University	LU	Foreign university
University Of San Francisco	USF	Foreign university
Aga Khan University Hospital Nairobi	AGA-N	Local hospital
Africa Population and Health Research Centre	APHRC	Local research organisation
University of California Berkley	UCB	Foreign university
University of Cape Town	UCT	Foreign university

Mobile ODT	MODT	Foreign for-profit
Nairobi County	N	Local government
SOS Children's Villages International	SOS	Local not-for-profit
Family Health Options	FHO	Local not-for-profit
Icahn University	ICA	Foreign university
Emory University	EMORY	Foreign university
University of Memphis	UOME	Foreign university
University of Michigan	MICHIGAN	Foreign university
Realtime Associates	RA	Foreign for-profit
World Health Organisation	WHO	Foreign not-for-profit
University of Kwa Zulu Natal	UKZN	Foreign university
City University Of New York	CUNY	Foreign university
New York Psychiatry Institute	NYPI	Foreign university
University of Strathclyde	SCLYDE	Foreign university
University College London	UCL	Foreign university
National Institute for Health Research Biomedical Research Centre	NIHR	Foreign research organisation
Gartnavel University Hospital	GUH	Foreign hospital
Kitale Hospital	KITALE	Local hospital
Telkom Kenya	TELKOM	Foreign for-profit
Baobab circle	BAOBAB	Local for-profit
Flare Kenya	FLARE	Local for-profit
Johnson And Johnson	JJ	Foreign for-profit
Isikcure	ISIK	Local for-profit
Boehringer Ingelheim	BI	Foreign for-profit
Ashoka	ASHOKA	Foreign not-for-profit
Mydawa	MY DAWA	Local for-profit
Ion Kenya	ION	Local for-profit
Health Information Systems		
Name of Organisation	**Abbreviations**	**Organisation type and location**

AMPATH	AMPATH	Local not-for-profit
United States Agency for International Development	USAID	Foreign not-for-profit
Moi University	MU	Local university
Indiana University	IU	Foreign University
University of Nairobi	UON	Local university
Ministry of Health	MOH	Local government
Moi Teaching and Referral Hospital	MTRH	Local hospital
Regenstrief Institute Inc.	RII	Foreign not-for-profit
VA HSR AND D CENTRE On Implementing Evidence Based Medicine	VA HSR&D	Foreign government
University of Washington	**UW**	Foreign University
Kenya Medical Research Institute	KEMRI	Local research organisation
World Bank	WB	Foreign not-for-profit
Amref Health Africa	AMREF	Local not-for-profit
Safaricom	SAF	Local for-profit
Kenya Medical Supplies Agency	KEMSA	Local government
Colombia University	CU	Foreign University
Japan International Cooperation Agency	JAICA	Foreign not-for-profit
University of Toronto	UT	Foreign University
Mosoriot Rural Health Centre	MRHC	Local hospital
Yale University	YALE	Foreign University
Uamuzi Bora	UB	Foreign not-for-profit
University of Durham	UOD	Foreign University
British Antarctic Survey Medical Unit	BASMU	Foreign not-for-profit
ABT Associates Company	ABT	Foreign not-for-profit
University of Oslo	OSLO-U	Foreign University
Savanah Informatics	SI	Local for-profit
Rockefeller Foundation	RF	Foreign not-for-profit
Clinton Health Access Initiative	CHAI	Foreign not-for-profit
HP East Africa	HP.EA	Foreign for-profit
Strathmore University	SU	Local university

Kajiado District Hospital	KDH	Local hospital
Société Europeanness des Satellites	SES	Foreign for-profit
MicroClinic Technology Limited	MTL	Foreign not-for-profit
Ogra Foundation	OF	Foreign not-for-profit
International Training and Education Centre for Health	I-TECH	Foreign not-for-profit
Elizabeth Glaser Paediatric Aids Foundation	EGPAF	Foreign not-for-profit
Centre for Disease Control and Prevention	CDC-USA	Foreign research organisation
University of California San Francisco	UCSF	Foreign University
Linkoping University	LPU	Foreign University
University of Amsterdam	UOA	Foreign University
Icahn University	ICA	Foreign University
Family Aids Care & Education Services	FACES	Local not-for-profit
Doctors Without Borders	MSF	Foreign not-for-profit
Lake hub Kisumu	LHK	Local not-for-profit
Africa Field Epidemiology Network	AFENET	Local not-for-profit
Brown University	BROWN	Foreign University
Vimak Company Limited	VIMAK	Local for-profit
University of Oxford	OXFORD	Foreign University
Intellisoft Limited	INTELLISOFT	Local for-profit
Innovative Canadians For Change	ICFOREIGN UNIVERSITYC	Foreign not-for-profit
University of Alberta	UAL	Foreign University
Ryerson University	RYU	Foreign University
Kenyatta National Hospital	KNH	Local hospital
National Aids & STI Control Programme	NASCOP	Local government
FIO Cooperation	FN	Foreign for-profit
Iridium Interactive	IRIDI	Local for-profit
Savannah Informatics	SI	Local for-profit
University of Kansas	UOK	Foreign hospital
University of Missouri	UOMI	Foreign University

Child Mercy Hospital	CMH	Foreign hospital
Global Health Innovations	GHI	Foreign not-for-profit
Other Forms Of eHealth		
Name of Organisation	**Abbreviations**	**Organisation type and location**
FHI 360	FHI	Local not-for-profit
Colombia University	CU	Foreign University
Moi University	MU	Local university
University of Washington	**UW**	Foreign University
Aga Khan University Hospital Nairobi	AGA-N	Local hospital
RTI International	RTI	Foreign not-for-profit
Kijani Consultancy	KIJ	Foreign research organisation
Brown University	BROWN	Foreign University
AMPATH	AMPATH	Local not-for-profit
Innovative Support to Emergency Diseases and Disasters	INSTEDD	Foreign not-for-profit
Regenstrief Institute Inc.	RII	Foreign not-for-profit
Population Council	PC	Foreign not-for-profit
Stanford University	STANFORD	Foreign University
University of California	UCSD	Foreign University
Indiana University	IU	Foreign University
Maseno University	MASENO	Local university
Christian Health Association of Kenya	CHAK	Local hospital
Siaya County	SIAYA	Local government
International Medical Equipment Collaboration	IMEC	Foreign not-for-profit
Uzima University	UU	Local university
Kisumu Medical and Education Trust	KMET	Local not-for-profit
ICAP At Colombia University	ICAP	Foreign not-for-profit
Centre for Public Health and Development	CPHD	Local not-for-profit
Merck & Co.	MERK	Foreign for-profit

Machakos Hospital	MACHA	Local university
Kenyatta National Hospital	KNH	Local hospital
Ministry of Health	MOH	Local government
Kenya Medical and Dentists Board	KMPDB	Local for-profit
Kenya Medical Association	KMA	Local for-profit
Kenya Paediatrics Association	KPA	Local for-profit
Emergency Medicine Kenya	EMK	Local not-for-profit
Daktari Kenya	DK	Local for-profit
Chanjo Plus	CHANJO	Local for-profit
Virginia Commonwealth University	VCU	Foreign University
University of Nairobi	UON	Local university
University of Victoria	UOV	Foreign University
Moi Teaching and Referral Hospital	MTRH	Local hospital
Orbis International	ORBIS	Foreign not-for-profit
Cisco Systems	CISCO	Foreign for-profit
Kijabe Mission Hospital	KIJABE	Local hospital
Telemedicine		
Name of Organisation	**Abbreviations**	**Organisation type and location**
Aga Khan University Hospital Nairobi	AGA-N	Local Hospital
Aga Khan University Hospital Mombasa	AGA-M	Local Hospital
Aga Khan University Hospital Dar es salaam	AGA-D	Foreign Hospital
Aga Khan University Hospital Kisumu	AGA-K	Local Hospital
University of Pennsylvania	UOP	Foreign University
Ministry of Health	MOH	Local government
Safaricom	SAF	Local for-profit
Penn State University	PENN	Foreign University
United Nations Industrial Development Organisation	UNIDO	Foreign not-for-profit
National Collegiate for Inventors and Innovators Alliance	NCIIA	Foreign not-for-profit
Child and Youth Empowerment Centre	CYEC	Local not-for-profit

Lehigh University	LU	Foreign University
mCare	MCARE	Local for-profit
AMD Global Telemedicine, Inc.	AMD	Foreign for-profit
Paul Chester Children's Hope Foundation	PCCHF	Foreign not-for-profit
Interview		
Name of Organisation	**Abbreviations**	**Organisation type and location**
Amref Health Africa	AMREF	Local not-for-profit
University of Nairobi	UON	Local university
University of Manitoba	UOM	Foreign University
Weltel	WELTEL	Local not-for-profit
Philips	PHILIPS	Foreign for-profit
Strathmore University	SU	Local university
Intellisoft Limited	INTELLISOFT	Local for-profit
Ministry of Health	MOH	Local government
Moi University	MU	Local university
Medic Mobile	MM	Foreign not-for-profit
mHealth Kenya	MH	Local for-profit
Safaricom Limited	SAF	Local for-profit
Nailab	NAILAB	Local not-for-profit
Afya Research Africa	ARA	Local not-for-profit
Ubuntu Africa	UBUNTUA	Local for-profit
Michigan School of Law	MSL	Foreign University
United States Agency for International Development	USAID	Foreign not-for-profit
Measure Evaluation	MEASURE	Foreign not-for-profit
Turkana County Government	TURKANA	Local government
Department for International Development	DFID	Foreign not-for-profit
University of Santa Clara	SANTA CLARA	Foreign University
Duke University	DU	Foreign University
Google	GOOGLE	Foreign for-profit
National Aids Control Council	NACC	Local government

Cochrane Library	COCHRANE	Foreign not-for-profit
Joanna Briggs Institute	JBI	Foreign not-for-profit
University of Adelaide	UAD	Foreign University
Us Government	USG	Foreign government
Savanah Informatics	SI	Local for-profit
World Health Organisation	WHO	Foreign not-for-profit
United Nations Children's Fund	UNICEF	Foreign not-for-profit
John Snow Inc.	JSI	Foreign for-profit
Kenya Medical Supplies Agency	KEMSA	Local government
University of Oslo	OSLO-U	Foreign University
East African Community Ministry of Health	E-MOH	Foreign government
Swedish International Development Agency	SIDA	Foreign not-for-profit
AMPATH	AMPATH	Local not-for-profit
Uasin Gishu County	UASIN	Local government
Baringo County	BARINGO	Local government
Jomo Kenyatta University of Agriculture and Technology	JKUAT	Local university
National Institute for Medical Research	NIMRI	Foreign research organisation
Makerere University	MAKERERE	Foreign University
Africa Centre For Systematic Reviews and Knowledge Translation	ACSRKT	Foreign not-for-profit
Mombasa PGH	CPGH	Local hospital
Centre for Disease Control and Prevention	CDC-USA	Foreign research organisation
University of Washington	UW	Foreign University
International Training and Education Centre for Health	I-TECH	Foreign not-for-profit
Palladium Group	PALLADIUM	Foreign for-profit
Pharmacy and Poisons Board	PPB	Local government
German Society for International Development	GIZ	Foreign not-for-profit
Nairobi County	N	Local government

Africa Institute for Health Development	AIHD	Local not-for-profit
Aga Khan University Hospital Nairobi	AGA-N	Local hospital
National Aids & STI Control Programme	NASCOP	Local government
Elizabeth Glaser Paediatric Aids Foundation	EGPAF	Foreign not-for-profit
Family Aids Care & Education Services	FACES	Local not-for-profit
Christian Health Association of Kenya	CHAK	Local hospital
ICAP At Colombia University	ICAP	Foreign not-for-profit
Kenyatta University	KU	Local university
University of California San Francisco	UCSF	Foreign University
Aura Safira	AS	Local for-profit
Pensoft	PENSOFT	Local for-profit
Funsoft	FUNSOFT	Local for-profit
World Bank	WB	Foreign not-for-profit
Moi Teaching and Referral Hospital	MTRH	Local hospital
Vanderbilt University	VU	Foreign University
Indiana University	IU	Foreign University
Purdue University	PU	Foreign University
Regenstrief Institute Inc.	RII	Foreign not-for-profit
Kenya Health Informatics Associations	KEHIA	Local not-for-profit
Kenya Medical Research Institute	KEMRI	Local research organisation
Ministry Of ICT	MOICT	Local government
ABT Associates	ABT	Foreign not-for-profit
Maseno University	MASENO	Local university
Kisumu County	KISUMU	Local government
University of Kabyanga	KABYA U	Local university
Kericho County	KERICHO	Local government
Rongo University	RONGO	Local university
Migori County	MIGORI	Local government
Masinde Muliro University	MASINDE	Local university
Kakamega County	KAKAMEGA	Local government
Astra Zeneca	ASTRA-Z	Foreign for-profit

Tech Care for All	TC4A	Foreign for-profit
CarePay	CAREPAY	Foreign for-profit
Afya Jijini	AJ	Foreign not-for-profit
Jhpiego	JHPIEGO	Foreign not-for-profit
Centre for International Development	CICD	Foreign not-for-profit
Kijabe Mission Hospital	KIJABE	Local hospital
St. Joseph Hospital	SJH	Local hospital
Centre for Health Solutions	CHS	Local not-for-profit
Intrahealth International	INTRAH	Foreign not-for-profit
University of Bergen	BERGEN	Foreign University
University of Gondar	GONDAR	Foreign University
University of Rwanda	RWANDA	Foreign University
Kenyatta National Hospital	KNH	Local hospital
Dalberg Research Limited	DALBERG	Foreign for-profit
Totohealth	TOTO	Local for-profit
GSMA	GSMA	Foreign not-for-profit